

EXHIBIT 1

CONFIDENTIAL – Contains Information Designated Confidential

**IN THE UNITED STATES DISTRICT COURT
FOR THE WESTERN DISTRICT OF PENNSYLVANIA**

CIVIL ACTION NO. 2:19-cv-00484-MJH

PennEnvironment, Inc. and Clean Air Council, *Plaintiffs*

and

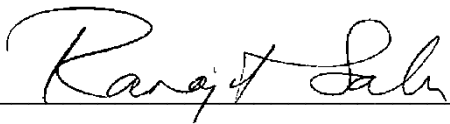
Allegheny County Health Department, *Plaintiff-Intervenor*

v.

United States Steel Corporation, *Defendant*

The Honorable Marilyn J. Horan

EXPERT REPORT
OF
DR. RANAJIT (RON) SAHU



ON BEHALF OF THE PLAINTIFFS

AUGUST 31, 2020

Information Required by the Federal Rules of Civil Procedure

The following is a list of the items required by the Federal Rules of Civil Procedure:

1. This report contains my opinions, conclusions and the reasons therefore;
2. I do not have any exhibits to be used in summary of, or support for, my opinions with this report other than what is provided with this report and other reports submitted in this action;
3. A statement of my qualifications is contained in Attachment A;
4. A list of publications I have authored within the last ten years is shown in Attachment B;
5. My compensation for the preparation of this report and my testimony is included in Attachment C; and
6. A statement of my previous testimony within the preceding four years as an expert at trial or by deposition is contained in Attachment D.

I have provided citations to documents I have relied upon in forming my opinions. In addition, I have relied upon my experience over the past four decades in support of my opinions. The opinions expressed in the report are my own and are based on the data and facts available to me at the time of writing.

I have been apprised that additional relevant and pertinent documents, discovery responses, and deposition testimony on subjects covered in this report have been received by Plaintiffs' counsel too recently for me to be able to review them, or are still to be produced in discovery. As a result, the opinions expressed in this report are tentative and based only on information I have been able to review so far. I reserve the right to revise these opinions as needed in a supplemental report.

I. BACKGROUND AND EXPERIENCE

I, Ranajit Sahu, have over thirty years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment; soils and groundwater remediation; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.); multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

I have a B.S., M.S., and Ph.D., in Mechanical Engineering, the first from the Indian Institute of Technology (Kharagpur, India) and the latter two from the California Institute of Technology (Caltech) in Pasadena, California. My research specialization was in the combustion of coal and, among other things, understanding air pollution aspects of coal combustion in power plants. I have over forty years of experience in power plant design, operation, and their environmental impacts, including discharges of thermal energy via cooling water.

I have provided consulting services to numerous private sector, public sector and public interest group clients. My major clients over the past twenty-one years include various steel mills, petroleum refineries, cement companies, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including the US Environmental Protection Agency, the US Dept. of Justice, multiple states, and various municipalities. I have performed projects in all 50 states, numerous local jurisdictions and internationally.

In addition to consulting, for roughly two decades, I taught numerous courses in several southern California universities including UCLA, USC, UC Riverside, Loyola Marymount University, California State University, Fullerton, and at Caltech, my alma mater.

I have and continue to provide expert witness services in a number of environmental areas discussed above in both state and federal courts as well as before administrative bodies.

Additional details regarding my background and experience can be found in my resume provided in Attachment A and in the list of publications and presentations provided in Attachment B. Attachments C and D contain a statement of compensation and my previous expert witness experience, respectively.

II. SUMMARY AND CONCLUSIONS

For this proceeding, I have been asked to provide opinions regarding various aspects of maintenance and facility design at the “control room” or “byproducts recovery” areas of US Steel’s Clairton plant, which process and remove pollutants from the coke oven gas generated at Clairton. I have also been asked to evaluate the performance of the flares at US Steel’s Irvin plant.

Based on my review of documents and other information relating to these US Steel facilities, other authoritative sources and reference materials, my tour of relevant areas of the Clairton and Irvin plants on November 14, 2019, as part of this litigation, and my education and extensive experience as a consultant and practicing engineer, I offer the following opinions:

The Clairton plant is a very old facility that is forced to operate with little to no margin for error, and therefore presents a constant air pollution threat to the community, for the following reasons:

(a) The plant (including the byproducts recovery systems in Control Rooms 1, 2 and 5) is old, appears to be poorly maintained, and has a recent history of major breakdown incidents;

(b) The design of the systems for treating coke oven gas (COG) to recover various by-products, and thereby create the “clean” COG that can be legally combusted at US Steel’s Clairton, Irvin and Edgar Thomson plants, contains numerous bottlenecks and provides inadequate redundancy of critical equipment. Therefore, when failures and breakdowns in these systems occur, as they frequently do, a problem at any point in the process flow can render all downstream processes inoperable; and

(c) The production of COG cannot be stopped or meaningfully reduced when such process interruptions occur, because it takes a long time (8 weeks or more, according to US Steel) to move the coke ovens themselves – the source of COG generation – to “hot idle” mode.

(d) The flares at the Irvin plant are inefficient and therefore ineffective pollution control devices. Sending large amounts of untreated COG to the Irvin flares, as US Steel does when the byproducts recovery systems are inoperable, creates high emissions of sulfur dioxide, hydrogen sulfide, particulate matter, and volatile organic compounds to the atmosphere.

Given this situation, US Steel needs do one or more of the following to achieve sustained compliance with its Clean Air Act permits and protect the communities around its plants:

(i) Target and achieve a standard of accident and failure prevention in the Control Rooms that is higher than it is currently achieving, and (because of the serious consequences of equipment failures and accidents) higher than a typical manufacturing facility achieves. This will require, as a first step, major audits of both equipment integrity and preventive maintenance systems for the byproducts recovery processes;

(ii) Re-design the Clairton plant to enable bypass of bottlenecks and points at which breakdowns have occurred, and/or to install backup air pollution control systems, so that byproducts removal and recovery systems are never off-line for any significant period of time, and flaring and other combustion of untreated COG is reduced to a minimum;

(iii) Design an enhanced or expedited coke oven hot idle procedure to very rapidly reduce or eliminate COG production, or install a COG recovery system to store large amounts of untreated COG when the Control Rooms are unable to operate; or, as a last resort,

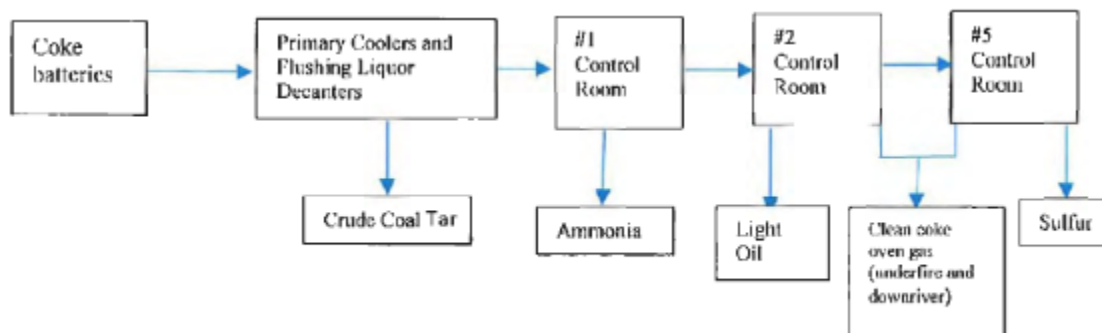
(iv) Shut down the Clairton plant if none of the measures above can be achieved in a reasonable period of time.

III. INTRODUCTION TO THE CLAIRTON PLANT

A brief introduction is provided about the Clairton plant in order to provide a basis for further discussions in this report. The descriptions are taken substantially from a report prepared by Engineering Design and Testing (EDT).¹

US Steel (USS) owns and operates a metallurgical coke production facility at Clairton, Pennsylvania. Metallurgical coke (coke) is produced by heating coal in coke ovens in order to expel volatile compounds, leaving behind a high purity carbon product – i.e., coke. The coke is then supplied as a fuel used for the production of iron at facilities both within and outside USS. At the Clairton Plant, 708 ovens are arranged into ten groups, known as batteries, that produce approximately 11-12 thousand tons of coke per day.

The volatile compounds that are produced during the coking process leave the batteries as a gas known as coke oven gas. The coke oven gas, which is high in methane and hydrogen content, but contains other chemicals and impurities, is collected and processed in order to permit the coke oven gas to be used as a fuel, either at the coke oven batteries or at other process units at the Clairton plant and at two USS steel plants. The sketch below shows the major process locations involved in processing the coke oven gas.



The three “Control Rooms” noted in the sketch above (i.e., #1 or No. 1; #2 or No. 2 and #5 or No. 5) are chemical processing plants which sequentially remove by-products from the coke oven gas, which is then used as fuel. For this reason Clairton is considered a by-product coke production plant.

Described in words, the coke oven gas which exits the individual coke ovens at approximately 1800 F, is first cooled or quenched as it is collected at the batteries, and then further cooled or quenched in the primary coolers. The cooling or quenching liquid, known as flushing liquor, is collected and routed back to the batteries for reuse, after tar is removed from the flushing liquor.

¹ EDT Report, May 10, 2019.

At the No. 1 Control Room, compressors (known as the Main Axi Compressors) pull the coke oven gas from the batteries and through the primary coolers. The Main Axi Compressors also boost the pressure of the coke oven gas to permit further processing in downstream equipment. In addition to compression at the No. 1 Control Room, the coke oven gas is further cooled (in the final coolers) to remove any remaining tar and naphthalene, and then processed to remove ammonia in the Phosam absorber.

The coke oven gas, minus tar, naphthalene, and ammonia, is then routed to the No. 2 Control Room, where a cryogenic process is used to condense and thereby remove light oil and sulfur compounds from the coke oven gas. Briefly, the cryogenic process utilizes large vessels, known as the main regenerators, which are filled with quartzite stones (the stones). The stones, which are maintained at a temperature of minus 258 F, cool the incoming coke oven gas, resulting in condensation/freezing of any water, light oil and some sulfur compounds upon the surface of the stones. The resulting high purity coke oven gas (mainly methane and hydrogen at this point but with some additional sulfur) leaving the main regenerators is then divided into two streams, totaling roughly 200 million standard cubic feet per day (MMscfd) – known as Underfiring and Downriver Gas. The cryogenic process at the No. 2 Control Room is unique. As US Steel itself notes:

“The #2 Control room cryogenic gas separation plant is unique to Clairton in the entire world coke making process. The cryogenic gas separation plant, designed by German company Linde, was installed in only a few coke plants around the world in the 1960s. Shortly after installation it was discovered that the cryogenic cold piping accumulates Nitric Oxide (NO) "gums" that become unstable and explode above (negative - 80F).”²

As part of its plan to safely take down No. 2 Control Room after the December 24, 2018 fire incident, US Steel noted a previous explosion at this same process area:

“It is a given that the cold process piping has accumulated these NO gums, as it has been in service since the plant was restarted after the 2009 explosion at #2 Control room.”³

Underfiring gas is used at the Clairton plant itself to heat the ovens at the coke batteries as well as at other process units such as boilers. Downriver Gas is used as a fuel for boilers at the Clairton plant power house, and for various heating requirements at two other USS facilities in the Mon Valley Works system (120 MMscfd) located downriver from the Clairton plant – namely the Irvin plant and the Edgar Thomson (ET) plant.

Since a primary focus of this litigation is a fire and explosion at the No. 2 Control Room on December 24, 2018, it is worth discussing the process activities at this part of the plant in additional

² USSP004379

³ USSP004379

detail. At a predetermined point in the operations of the main regenerators noted above, the quartzite stones become covered with the compounds removed from the coke oven gas (i.e., water, light oils and some sulfur compounds). These compounds are periodically removed from the stones by pulling a strong vacuum on the main regenerators (so that they can then cycle and remove more water, light oils and sulfur compounds), using additional compressors known as vacuum machines. The gas removed by the vacuum machines, known as sublimation gas ("Sub Gas"), undergoes additional processing to remove the light oil and to increase the concentration of sulfur compounds in it. This sulfur-rich Sub Gas which leaves the No. 2 Control Room is known as Carbonate Feed Gas, and is routed to the No. 5 Control Room, where the sulfur, along with other trace contaminants, are removed. The resulting "clean" coke oven gas (which still contains some level of impurities) is added to the Downriver fuel system.

Production Flow Diagram

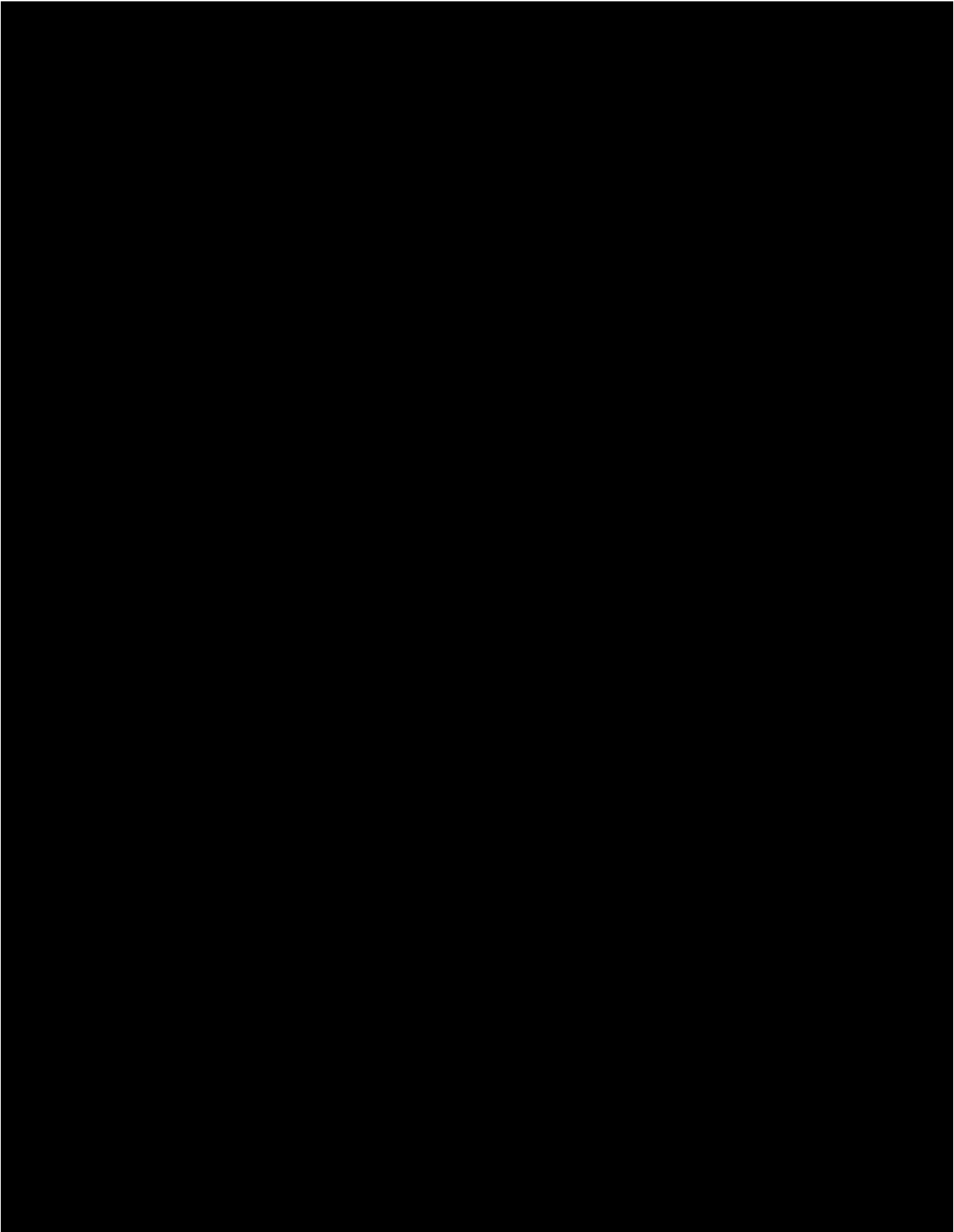
⁴ USSP017865

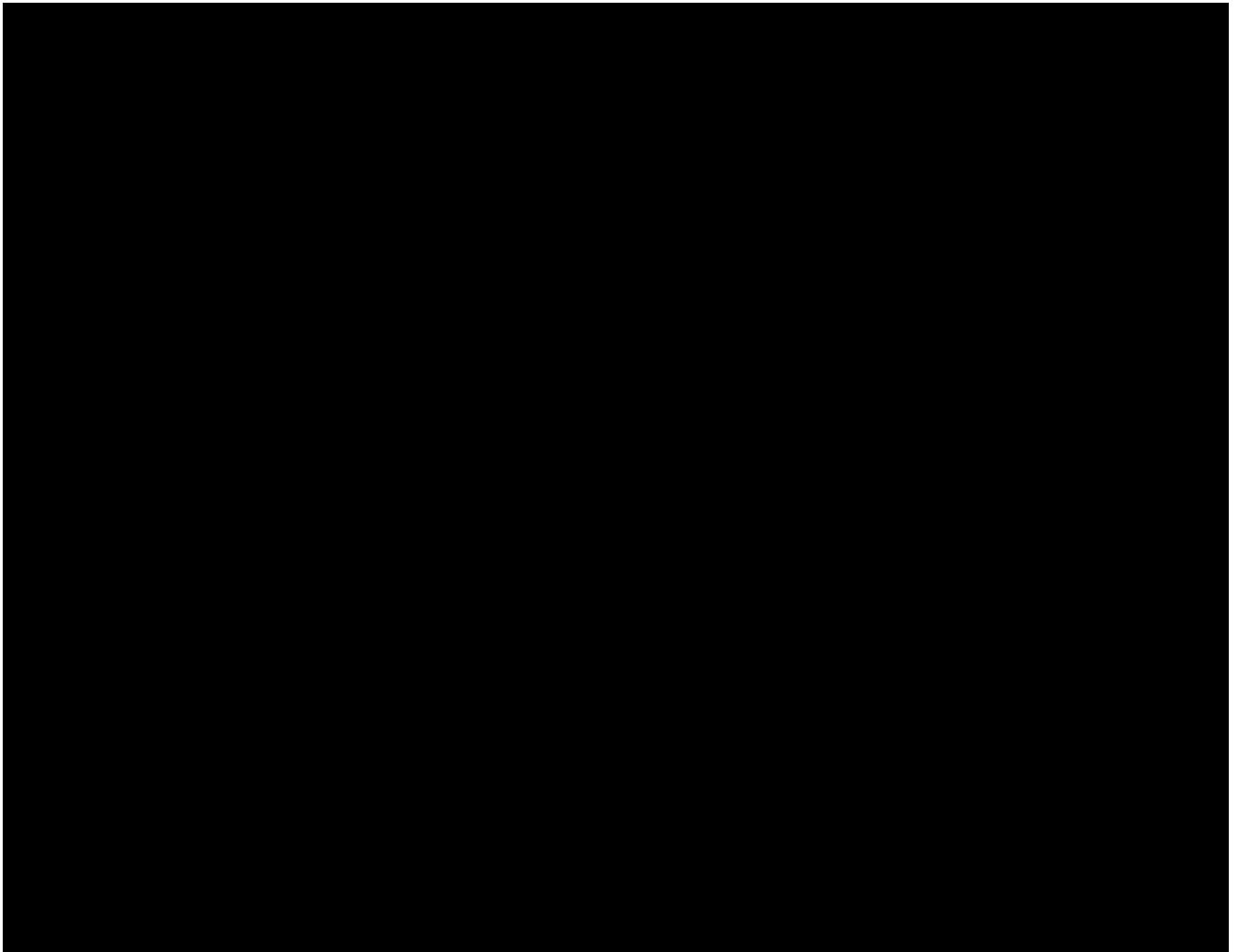
As noted above, the three Control Rooms are chemical processing units. As such, they are not meaningfully distinguishable in function and operation from other chemical plants. The photographs below generally show some of the Control Room areas. They were taken during my site visit to the plant on November 14, 2019.











IV. CONCLUSIONS DRAWN FROM THE DECEMBER 24, 2018 INCIDENT

The description of this event and its causes are discussed at length in various other documents in the record, including a brief “Narrative of Event,”⁵ and two reports by EDT, the first dated May 10, 2019⁶ and a Supplement dated December 2, 2019.⁷ I provide extensive excerpts from these two EDT reports in order to provide a basic understanding of this event and its preventable causes.

Picking up from the plant description provided in the prior section, the No. 2 Control Room is equipped with 16 vacuum machines, twelve for servicing the main regenerators, two for use in the light oil recovery system (the light oil vacuum machines), and two intended as spares for either the main or light oil regenerators. At full coke production rates of roughly a little over 4 million tons per year, ten vacuum machines are required to process the 200 MMscfd of COG and two are available as spares. These vacuum machines are designated as C-500, C-503, C-506, and C-509 through C-533 (with gaps in the numbering). The vacuum machines discharge the Sub Gas to a pressure level sufficient to permit processing in the downstream equipment to remove light oil at the No. 2 Control Room and sulfur compounds in the subsequent No. 5 Control Room. Therefore, if there is a problem at the No. 2 Control Room that renders the vacuum machines unavailable, the COG from the No. 1 Control Room cannot be cleaned of undesirable compounds prior to being routed into the Underfiring and Downriver fuel systems.

Based on its analysis of the December 24, 2018 incident, EDT reported the following sequence of events (with emphasis added):

- “1. *Long term corrosion* [due to water leaks from the roof] takes place at the [fire system] deluge pipe hangers and in couplings used to join the threaded sections of pipe [located close to the ceiling in the building with the vacuum machines].
2. Sufficient thinning of a coupling wall, due to corrosion, results in an overload fracture and detachment of a section of deluge piping.
3. The falling deluge piping strikes and severs the one-inch lube oil supply line to the suction end bearings on C-521 second stage.
4. The lube oil flowing from the severed one-inch lube oil supply line is ignited by the temperature of a nearby steam line.
5. The large, increased flow of the lube oil issuing from the severed one-inch lube oil supply line is sufficient to result in an increase in pressure drop across the oil

⁵ USSP013793

⁶ Engineering Design and Testing (EDT), Report May 10, 2019, USSP002887-3030

⁷ USSP007787-7832

cellar lube oil filters, along with a corresponding drop in the lube oil supply pressure [to multiple compressors].

6. C-521 experiences a low lube oil alarm - this is the first alarm associated with the incident. The hydraulics of the system prevented the low lube oil trip from activating.

7. The second stage [of C-521], male bearing at the suction end (supplied with lube oil from the severed line), experiences an increase in temperature, then [triggering] a high temperature alarm.

8. The first stage male bearing at the suction end of the first stage [of C-521] experiences a drop in temperature, indicating the shaft had fractured. The *shaft had a crack across 80 percent of the cross-section*; the additional bending stress due to misalignment, associated with the loss in lube oil at the second stage bearing, was sufficient to complete the final fracture of the shaft.

9. Fracture of the shaft results in rotation of the still attached coupling spacer/hub on the second stage, introducing large cyclic forces/vibration sufficient to result in fracture of anchor bolts and loosening of bolts, including the bolts on the discharge line.

10. With the first stage non-operational, and an absence of Sub Gas flow through C-521, the suction pressure on the still operating second stage decreases to a vacuum. During the same timeframe, an increase in the suction pressure on the Sub Gas header takes place - due to non-operation of the first stage.

11. Bearing temperatures continue to rise on the suction end of the second stage to the point of softening/melting of the Babbitt.

12. The Sub Gas suction header experiences a larger increase in pressure during the next regenerator cycle.

13. The suction end bearings on the second stage experience melting; the total loss of Babbitt (0.375") accompanied by the vibration experienced by the second stage, result in destruction of the male carbon seal at the suction end. The damage to the suction end seal and the presence of a high vacuum condition at the suction end of the second stage (due to non-operation of the first stage), results in a decrease in pressure in the seal vacuum system.

14. *Sub Gas is discharged from the eight-inch discharge line* after the bolts had vibrated loose, dropping away and permitting the flanges to separate. The LEL gas alarm is triggered.

15. A large flow of Sub Gas issues from the separated discharge flanges *due to a malfunction of a check valve in the discharge line: Corrosion had resulted in detachment of the flapper intended to prevent the backflow of gas through the check valve.*

16. The Sub Gas issuing from the separated discharge flanges is ignited by the lube oil fire.

17. The fire alarm is triggered by the burning Sub Gas.”

EDT summarizes as follows:

“[G]iven the sequence of events and examination of the incident scene, the origin of the fire was at C-521, with the initial fuel source being the lube oil issuing from the severed one-inch lube oil supply line. The close proximity of steam lines, operating at temperatures greater than the flash point of the lube oil, served as the ignition source for the lube oil being discharged by the severed line. Final fracture of the first stage shaft was initiated by misalignment that took place when the second stage suction end bearings lost lube oil flow. Severe vibration, associated with continued rotation of still attached coupling components at the second stage, took place after the shaft fracture. The vibration resulted in the separation of flanges at the discharge of C-521, producing a flow of flammable Sub Gas which was ignited by the already burning lube oil.”

It is evident, and EDT confirms, that:

- “[T]he root cause of the incident was due to long term corrosion, which initiated the falling deluge lines that severed the one-inch lube oil supply line.” However, this fire was then exacerbated by the complete fracture of the (already severely cracked) first stage shaft of C-521, and the release of the Sub Gas. Thus, per EDT, the following contributed to the extensive damage experienced by the No. 2 Control Room:
- Fracture of the first stage shaft due to corrosion-initiated fatigue produced vibration of the second stage sufficient to separate the discharge flanges that resulted in the discharge of Sub Gas.
- Corrosion in the discharge line check valve, which prevented proper operation of the check valve, resulting in the back flow of a large volume of Sub Gas through the separated flanges in the discharge line.”

EDT also states that even absent severing of the lube oil line of C-521 via the fall of the deluge piping from the ceiling:

“...fracture of the first stage shaft [of C-521] is expected to have taken place at some point in the near future, given the advanced propagation of the fatigue crack. Assuming said fracture takes place during operation (as opposed to starting/shutdown of C-521), the fracture is expected to have resulted a sequence of events similar to the incident, producing separation of the eight-inch discharge flanges, release of Sub Gas, and activation of the LEL Alarm. However, ignition of the Sub Gas would not have taken place, absent the burning lube oil.”

In its December 2019 Supplemental Report, EDT provides additional details on the failure of the deluge piping and the lack of maintenance leading up to it, which initiated the sequence of events of the December 24, 2018 catastrophic event. EDT states:

“...USS personnel responsible for the testing, inspection and maintenance of the deluge system were interviewed with regard to frequency of the testing/inspection, as well as any recent significant findings with regard to maintenance issues. USS inspection and test reports for 2017 and 2018 were provided for review, along with an inspection report prepared by a third party *in 2003....*”⁸ (emphasis added)

EDT states:

“The deluge system is known as a dry system, whereby water is not present inside the piping above the vacuum machines. The fire water supply to the north and south sections is controlled by two control valves (one for each section) that are opened by manual activation of a pull station, located at the south end of the No. 2 Control Room.

...

Mr. Aaron Gilbert, Fire Chief with USS, reported that the deluge system is inspected and trip tested by USS fire department personnel every year, with a report generated to document said inspection/testing. *However, the testing does not involve filling of the piping above the vacuum machines, i.e., a full discharge test.* The test is conducted by first opening a drain valve located downstream of the control valves, then tripping the system to verify the operation of a pressure switch used to indicate the presence of water flow into vertical pipes (known as risers), that connect to the north and south sections of the system. The system is shutdown prior to water accumulating to any significant amount inside the risers. *USS is not aware of any time, since the original installation, that the deluge system above the vacuum machines had been activated, other than during the incident/fire that took place in December 2018.*” (emphasis added)

This is unfortunate because if, in fact, a full discharge test been conducted annually, it is likely that there would have been leaks from the corroded and weakened sections of the deluge pipe that did fail, initiating the unfortunate chain of events on December 24, 2018. This is but one example of how preventable the accident was. EDT goes on to state:

“In addition to the trip test, a visual inspection of the deluge system components and piping is conducted. It is noteworthy that the deluge system headers and laterals are located approximately 45 feet above the floor vacuum machine operating floor. As such, a detailed/close-up visual examination *is not feasible*. In fact, a review of the inspection reports for 2017 and 2018 inform that the pipe support hangers were not checked in 2018, but were checked in 2017, *from the floor level only....* Given

⁸ EDT Suppl. Report, p.3

*the arrangement of the vacuum machines inside No. 2 Control Room, and the position of the deluge system headers, it is not possible to access the deluge system to the extent required to assess the condition of components.”*⁹ (emphasis added)

Of course, just because components are located near the ceiling does not make them inaccessible for inspections, per se. US Steel personnel could have used the overhead crane present in this building or other devices such as scissor lifts to access these elevated components.

Discussing prior inspections, EDT noted:

“USS provided a report of the only known detailed inspection of the deluge system at No. 2 Control Room, conducted by Simplex Grinnell (Grinnell) in 2003. The inspection addresses not only the condition of the deluge control valves, *but identified a number of locations where piping supports (hangers) were deficient or required replacement.* However, the report is silent with regard to the condition of the hangers above the vacuum machines, suggesting that no issues were identified (or that the location of the hangers was such that access could not be attained)... the 2003 Grinnell inspection report identified missing hangers and hangers requiring replacement in other, more accessible locations at the No. 1 and 2 Control Rooms. A post incident inspection of No. 1 Control Room deluge systems identified a number of missing/loose hangers. An inspection of the deluge system beyond the fire location (south end of No. 2 Control Room) revealed loose hangers and sagging headers, placing a bending strain on the reducing tee fittings. Given the condition of deluge system supports/hangers are of the same vintage as those used in the deluge system above the vacuum machines, and the mechanism necessary for impact of the deluge piping at C-521, all indications are that long-term deterioration had affected the integrity of the hangers/supports that comprised a portion of the deluge system above the vacuum machines, in particular the location above C-521 and C-524.”¹⁰ (emphasis added)

Noting how extensive the corrosion was in the deluge piping component (and thereby confirming how long it had been since any inspection), EDT states:

“[The extensive corrosion experienced by the 4"x2"x4" reducing tee (the reducing tee) was very localized. The top half of the reducing tee experienced external corrosion to the extent that no metal remained in some locations, transitioning to paper-thin metal near the 2-inch branch and sides of the reducing tee.”

Finally, as to inspection and maintenance of the deluge system EDT noted:

“All inspections of the deluge system are conducted by USS Fire Protection personnel, with any maintenance items identified by the inspections addressed by a third-party contractor. *USS reported that no work, either by USS personnel, or a*

⁹ EDT Suppl. Report, p. 10.

¹⁰ EDT Suppl. Report, p. 11. (internal citations omitted).

third party had been conducted on the hangers/supports located on the portion of the deluge system above the vacuum machines. The elevation of the deluge system above the vacuum machines prevented USS from conducting a close-up inspection/evaluation of the condition of the hangers/supports. It is noteworthy that USS reported during the demolition and replacement of the existing deluge system, numerous hangers were found loose or not providing adequate support of the piping. Only when the existing deluge system had been accessed close enough to conduct the demolition work, was the condition of the hangers recognized.”¹¹
(emphasis added)

Based on the description of the accident and its root and proximate causes, it is my opinion that the accident was preventable by a robust inspection and preventive maintenance program and by better plant design. Many individual actions and combinations of actions could have prevented or minimized the accident; in my opinion (as further explained below), the failure to take any of these actions provides one body of evidence among many of systemic deficiencies in US Steel’s operation and maintenance of the Control Room areas of the Clairton plant:

In addition to the failure to identify and remedy extreme corrosion and deficient supports in the deluge piping system, the roof over the vacuum building was also not maintained properly, leading to water leaks in the first place and the subsequent corrosion and failure of components. And even without the leaking roof, as EDT notes, the shaft in compressor C-521 was near failure itself. Add to that the severe corrosion of the check valve, which prevented its proper operation and thereby allowed COG to escape. Then there is the improper design of the lube oil failure detection system (described below). On top of which is the improper design of the deluge piping system and its location, which led US Steel to fail to properly inspect it – another preventable cause in my opinion.

More specifically, my assessment of the specific failures which caused the December 24, 2018 event are as follows.

1. Leak in roof of No. 2 Control Room – failure to inspect and improper design

EDT concluded there was a roof leak that allowed water to drip, probably for years, onto a section of the deluge piping. This leak was preventable. It is of course serious that US Steel allowed leaks in the roof of a building housing sensitive equipment that processes highly flammable, toxic, pressurized gas to persist or go undetected for years. And, it is clear that US Steel was aware of problems with the deluge system – i.e., loose and missing hangers – as far back as 2003. Up-close inspection of these would likely have led to discovery of the roof leaks. US Steel could have then implemented repairs to corroded sections of the deluge system, modified its design as needed, and fixed leaks in the roof. Proper annual inspections since 1966 (when the Control Room No. 2 was installed) or at least since 2003, after the last external inspection, could have prevented this.

¹¹ EDT Suppl. Report, p. 14-15.

When replacing the roof after the fire, US Steel determined that use of an all steel design is more appropriate than the pre-existing rubber roof (installed in 1999) that leaked and was then damaged by the fire.

2. Improper design of the lube oil failure tripping system.

At the time of the fire, the axial compressor lube oil tripping system was designed in such a way that it was rendered inoperable when power was knocked out – as occurred when the deluge piping fell. A properly designed tripping system may have reduced the size and severity of the fire by reducing the continued flow of lube oil to the fire. As US Steel subsequently figured out, the basic design of the tripping system was flawed. It is my understanding that US Steel has upgraded the tripping mechanism on the axial compressors by reversing the power scheme, so that the tripping mechanism is constantly energized and that the trip will engage whenever power to the tripping mechanism is interrupted, at a cost of approximately \$35,000. It is not clear, however, if US Steel has conducted a systematic review of its many other similar lube oil and other trip systems at Clairton and the other Mon Valley Works plants.

3. Cracked rotor shaft in vacuum compressor C-521.

As noted earlier, EDT found that one of the rotor shafts in compressor C-521 was already cracked 80% of the way through its full diameter before the fire. The continued use of that rotor shaft is almost impossible to explain, given that US Steel had supposedly inspected this compressor just a few months before the fire (i.e., around October 2018). It is my opinion that a proper inspection of such critical equipment would have detected this cracking, and that – if detected – a responsible company would have replaced such a severely cracked shaft. This failure points to significant deficiencies in US Steel's inspection programs for the compressors, which are the work horses of its COG processing equipment.

4. Severe corrosion of a check valve, resulting in its failure.

Again, as noted earlier, EDT found that the check valve in the compressor C-521 offgas pipe would have prevented the backflow of Sub Gas into Control Room 2, but severe corrosion rendered it inoperable. An operating check valve would have prevented the small lube oil fire from exploding into the much larger Sub Gas fire. Failure to replace a corroded check valve is inexcusable and points to the utter lack of US Steel's ability to maintain even its most critical equipment. While the documents describing US Steel's current maintenance program are full of acronyms, jargon and descriptions of maintenance systems that may sound good on paper, but US Steel did not have any boots on the ground to actually conduct proper inspections, or to create meaningful prioritization of maintenance needs to prevent failures.

Further, my opinion of US Steel's maintenance practices is not a case of hindsight being 20-20. It is of great significance that the December 24, 2018 fire in No. 2 Control Room was by no means a rare occurrence. The following is a listing of other fires and compressor failures in No. 1, No. 2, and No. 5 Control Rooms at Clairton:

- 1997: C-135 compressor failure (corrosion fatigue) and fire – Control Room 1

- 2009: Explosion and fire (welding incident) – Control Room 2
- 2015: C-630 compressor failure (fractured rotor shaft) and fire – Control Room 2
- 2018: Compressor trips and month-long desulf unit outage – Control Rooms 1 and 2
- 2019: Electrical fire – Control Room 1
- Other maintenance issues as revealed in documents obtained in discovery and in ACHD inspections, described below

Given this history, and given the significant deficiencies in how US Steel has implemented (or failed to implement) maintenance processes at the Clairton plant control rooms as I discuss next, it is my opinion that a thorough, third-party, baseline equipment integrity and maintenance evaluation is essential. Without such an evaluation, and without appropriate follow-up steps, similar accidents (with, perhaps, even more dire outcomes) at Clairton cannot be avoided.

V. ADDITIONAL EVIDENCE OF MAINTENANCE DEFICIENCIES AT CLAIRTON

This section discusses additional evidence relating to maintenance issues at the Clairton plant control rooms. This evidence provides additional bases for my opinion that there needs to be a robust oversight by a third-party monitor in order to address maintenance issues at the plant and establish a robust preventive maintenance program, and that such a monitor should oversee operations until such time as a robust program is in place. In particular, I discuss here evidence that points to systematic deficiencies in the maintenance program and apparent design flaws in the plant.

There are many lines of evidence and many examples that all point to a systemic failure of maintenance at the Clairton plant's control room areas. These include but are not limited to:

- the fact that multiple, diverse and fully preventable failures combined to cause the December 24, 2018 fire and explosion incident and exacerbate its severity, as discussed above in Section IV and in the referenced investigation (EDT) reports;
- a history of failures involving critical equipment like axial compressors, also noted at the end of Section IV;
- post-fire changes and upgrades to equipment and procedures that should have been taken much earlier; and
- evaluations by outside consultants such as Marsh, McKinsey, and EDT.

After a brief introduction, I provide examples of these and other lines of evidence of maintenance deficiencies at Clairton.

The Control Rooms at the Clairton plant are essentially chemical process units in form and function. A basic, comprehensive maintenance plan for a chemical processing plant begins with a complete and thorough assessment of the condition of all equipment as it relates to the ability of each component to perform intended functions. Based on the documents I have reviewed, such a thorough baseline assessment of the Control Rooms has not been conducted recently, or at any time within the scope of the records I have seen. In fact, I have found no indication that US Steel has an effective, comprehensive maintenance program for the Clairton plant and its Control Rooms.

At Clairton, inspections of the facility and follow-up actions appear to be ad-hoc, sporadic, not thorough, and not systematic. This includes inspections I have reviewed that were conducted by third parties such as insurance carrier representatives.

It is also clear from the records I have reviewed that even when inspections identify items that need to be fixed, there is considerable delay in implementation. And implementation appears to be constrained by available funding. Thus, relying on US Steel's own reports and records, the maintenance program at Clairton seems to be driven and constrained by available resources. What I mean by that is that the plant fixes what it can within the budget allocated, as opposed to having maintenance decisions driven by need.

Resource constraints are of course always a factor in any maintenance plan at any facility. But the deficiency in maintenance at Clairton begins with US Steel's failure to conduct the type of comprehensive assessment of needs described at the beginning of this section. As a result, it is impossible to develop a potential list of all maintenance items and, importantly, to rank the criticality or priority of each one. Any reasonable risk mitigation program should at least allocate enough maintenance budget to clear the most critical items. But if one does not start from a comprehensive baseline, it is impossible to know if critical items have been missed. Thus, US Steel's existing prioritization system that guides expenditures of available maintenance funds (and, indeed, the setting of the maintenance budget itself) is not grounded in a comprehensive assessment of needs. Such grounding is critical, especially for an old plant like Clairton.

This is a basic flaw that can only be fixed by conducting a thorough inspection of all plant areas by a third party contractor (*i.e.*, a fresh pair of eyes) with the requisite expertise.

I now provide examples of multiple lines of evidence showing the numerous deficiencies in US Steel's maintenance programs.

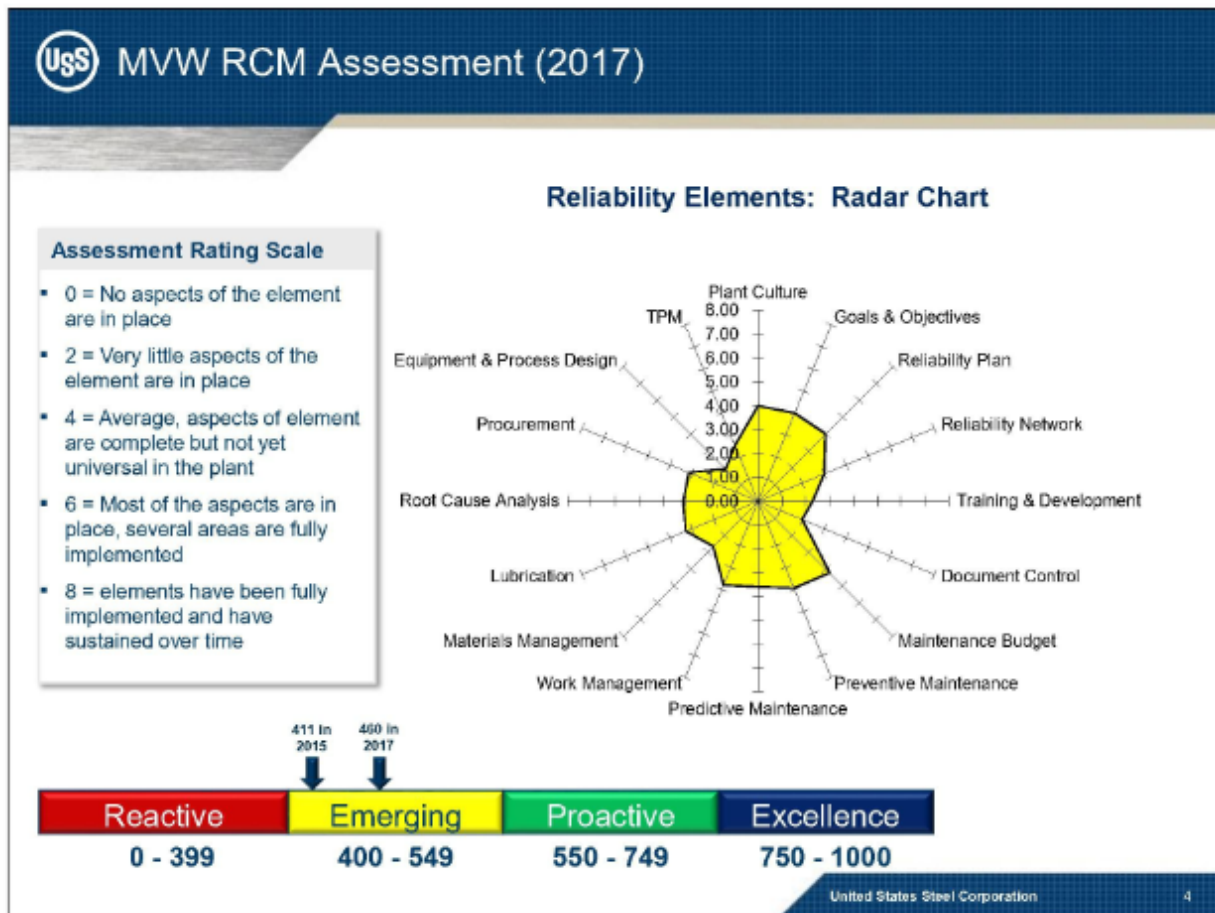
First, I start with evidence, as shown in the following excerpts, that US Steel was focused on expense reduction at its Mon Valley Plants, including Clairton, in the years leading to the December 24, 2018 incident. [REDACTED]

[REDACTED]

[REDACTED]

[REDACTED]

Second, the lack of maturity of US Steel’s reliability program, even as recently as 2017, which was after at least 2 years of implementation of its “reliability centered maintenance” (RCM) program, is evident in the slide below.¹³



As the figure above shows, maintenance related items, such as the budget, as well as preventive and predictive maintenance, all are rated at “4” or less out of 8, indicating that only “aspects ... are complete but not yet universal in the plant.”

Third, the complete lack of operating margin for critical equipment such as the vacuum machines in the No. 2 Control Room is clear from the excerpt below,¹⁴ which shows that only 9 vacuum machines, with no spares, were available in the months leading up to the December 24, 2018 accident. Recall that 10 machines are needed at the plant’s rated capacity of 4 million tons of coke production per year.

¹³ McKinsey-USS-002705

¹⁴ McKinsey-USS-000055



#2 CR Vacuum Compressor Status (9+0)

Accomplishments

1. LO Plant – sub2 suction header isolated and demo started
2. #1 Boiler – found leak and repairing, outage is on-going
3. Keystone Road Way - Big Crane and Rental Boiler removed.

Concerns / Opportunities

1. Spare Vacuum Compressors – see #2 CR Vacuum Compressor Status block
2. Manpower (Hourly) – 14 short
3. 1st Unit Suction Main – restricted and need to take the upper line out of service to clean out.
4. T-203 Final Cooler – 2 final cooler operation

C-500 – Offline, needs both stages replaced
 C-503 – Online, 2nd stage replaced July-18
 C-506 – Offline, 2nd stage running rough needs both stages
 C-509 – Online, 2nd stage seals leaking (456 days)
 C-512 – Online, 1st stage timing gear noise
 C-515 – Online, both stages replaced July-18
 C-518 – Offline, needs both stages replaced
 C-521 – Online, 2nd stage replaced Oct-18
 C-524 – Online, both stages replaced Sept-18
 C-527 – Online, 1st stage replaced July-18
 C-530 – Online, both stages replaced June-18
 C-533 – Online, both stages replaced July-18
 C-539 – Offline, Sub2 suction valve MOV needs replaced, shut down July-18 for 2nd stage seal leakage
 C-542 – Spare, both stages replaced July-18
 C-545 – Offline, empty pad. These machines went to 515
 C-548 – Offline, shut down July-18 for 1st and 2nd stage seal leakage

Goals

1. F-Line – continue pipe installation 50% complete
2. T-203 – continue adjust vessel internal support for demister/LO spray unit.
3. LO Plant - Finish demo of phase 2. Finish washing stones.
4. #1 Boiler – continue outage work
5. C-1 Column – Column switch outage on Tuesday
6. C-542 – have available once 596 oil cellar is complete.
7. Quad 4 – continue turn around once dome crack is repaired on 4-D.

The lack of vacuum machine capacity even in the months after the No. 2 Control Room became operational after the December 24, 2018 fire, is evident in the email excerpt below.¹⁵

¹⁵ USSP014673

Axi machines with stub rotors remaining

From: "/o=exchangelabs/ou=exchange administrative group (fydibohf23spdlt)/cn=recipients/cn=22ef50b9b49f4daeb419455a9a40c43b-kurt a. bar"
To: "Burritt, David B" <dbburritt@uss.com>
Cc: "Greenstein, Sara A" <sgreenstein@uss.com>; "Rudge Jr, Robert C" <rcrudge@uss.com>; "Rhoads, Mike S" <mrhoads@uss.com>; "Jeffrey, Mark A" <mjeffrey@uss.com>; "Zelenski, Steve J" <szelenski@uss.com>; "Kerns, Kevin J" <kjkerns@uss.com>; "Weston, Owen B" <oweston@uss.com>
Date: Tue, 18 Jun 2019 15:12:04 +0000

Dave-

As requested,

The failed axi compressor yesterday, C-533 **DID NOT** have any stub shafts. There are only (2) machines remaining in the plant with stub shaft rotor repairs. Both are located in the #2 CR.

C-509 2nd stage - male discharge end

C-542 1st stage - all (4) shafts

At this time, we can not take these machines out-of-service due to the need for every available machine to process 100% of the gas. As a precaution after the Dec 24th fire, we stopped the practice of using stub shafts going forward, however

Kurt Barshick
General Manager- Mon Valley Works
United States Steel Corporation
Office 412-675-2600
Cell 205-381-5144
kbarshick@uss.com

Fourth, and as an example of the poor condition that other plant components were allowed to reach, in this case the supply and return lines to the cooling tower, see the email excerpt below, indicating the lines were “rotted ‘coke can thin’ and were on the verge of failing. This would have shut down all of gas recovery/byproducts (#1, #2 and #5 CR’s).” It appears that the imminent failures of these deteriorating components, as described in this April 1, 2019 email, were only discovered and averted because the December fire required significant inspection and repairs to the areas containing this equipment.¹⁶

¹⁶ USSP014677

#2 CR ancillary work

From: "Barshick, Kurt A" </o=exchangelabs/ou=exchange administrative group (fydibohf23spdlt)/cn=recipients/cn=22ef50b9b49f4daeb419455a9a40c43b-kurt a. bar">
To: "Kerns, Kevin J" <kjkerns@uss.com>
Date: Mon, 01 Apr 2019 21:04:29 +0000
Attachments: #2 Control Room Photos 29 Mar 2019.pdf (3.5 MB); #2 Control Room Photos 15 Mar 2019.pdf (4.44 MB)

Both PDF's contain photos of

1. the cooling tower water supply/return lines. These lines were rotted "coke can thin" and were on the verge of failing. This would have shut down all of gas recovery/byproducts (#1, #2, and #5 CR's)
2. Light oil plant sub gas piping replacement. Likewise, these lines were corroded thin and failing. They were replaced with stainless steel piping.
3. Photo below is of high line foul gas piping, valves, etc. There were several pipe clamps and patches on these lines that are impossible to repair unless #2/#5 CR's are down.

In summary, once we restart the Chemicals/Byproducts plant, we will be in very good shape with process stability through this work and 2018 light oil plant outage.

Fifth, the following excerpts are taken from a recent (August 21, 2018) "Property Risk Evaluation Report" focusing on the Clairton plant that was conducted by an outside company called Marsh Risk Consulting (USSP007840-7913). These excerpts provide specific examples of the ad-hoc nature of the inspection and maintenance programs at US Steel's Clairton plant, and have particular relevance for risk prevention at the Control Rooms.

Example 1¹⁷ – Overall Risk Management Program Inadequacy

In the excerpt below, Marsh mentions a "Risk to Manage" program but it is not clear how the four listed items, although substantial (in fact, one concerns the "Axial-Compressor Operation at the No. 1 Control Room"), were identified and ranked, and what other items were excluded and why. The report provides no evidence of a systematic, inspection-driven process of identification of candidate risks or the criteria used to create the subset of "key" risks.

¹⁷ USSP007847

Key risks associated with the Clairton Plant that are considered critical to the site are identified as Risk to ManageSM and include the following:

1. Reliability and protection of the Axial-Compressor Operation at the No. 1 Control Room Process Area.
2. The reliability of the electrical supply to key plant operations.
3. Mechanical integrity and reliability of production equipment.
4. Protection of the Keystone Cooling Tower.

I have also highlighted in red one broad category that made the above list: “mechanical integrity and reliability of production equipment.” One item falling within this general category is examined in my Example 2, below.

In addition, Marsh noted¹⁸ that in 2018, prior to the December 24, 2018 fire, “newly formed” Project Management Office (PMO) groups had been established throughout US Steel, tasked with conducting risk assessments and identifying “top” projects for risk reduction at each of the company’s plants. How this program was implemented at Clairton and how projects were identified and prioritized is not clear, although the report mentions that the top projects at Clairton included only one item related to the Control Rooms: the replacement of the No. 1 Control Room Final Cooler.

Example 2 – Mechanical Integrity and Reliability¹⁹

The inadequacy of US Steel’s (and its insurance carrier’s) assessment of maintenance needs is evident in this example.

¹⁸ USSP007861

¹⁹ USSP007850

| RTM ID | RTM-2015-03 |
|------------------|--|
| RTM summary | Mechanical integrity and reliability of process equipment. |
| Current Controls | <p>The plant has implemented several control measures to help mitigate the various machinery and equipment hazards for critical process operations.</p> <p>Inherent reliability was engineered into the plant with the n+1 redundancy methodology. Critical operations are provided with in-line spare equipment.</p> <p>U.S. Steel has a corporate computer controlled equipment tracking system to inventory all spare equipment for the entire company. Capital spares are maintained for most critical equipment such as axial compressors, drive motors, armatures, fans, gears, gear sets, conveyor belts, pressure relief valves, electrical breakers, etc. Spares are maintained on-site in the materials management warehouses on the south side of the site.</p> <p>The plant has an established preventative and predictive maintenance program for rotating equipment, high corrosion areas, critical equipment, etc. to maintain and service this equipment in order to help prevent unplanned interruptions to production.</p> <p>Lube oil analysis, vibration analysis on rotating equipment, and infrared testing of motors and electrical systems are conducted on a regularly scheduled basis.</p> <p>The plant's well-established Process Safety Management program</p> |

| RTM ID | RTM-2015-03 |
|--------|---|
| | (especially the Process Hazard Analysis, Management of Change, and Mechanical Integrity components) helps manage the reliability of equipment in hazardous process areas. |

The Marsh report discusses “n+1 redundancy” (i.e., having a spare, which is the +1) without any citations or process details, such as which equipment actually have such +1 redundancy. It is clear and extremely important to note that at the Control Room and by-products plant level, there is *no* n+1 redundancy in the event of interruptions to the process flow of COG treatment. If there were, the Clairton plant would have been able to continue to operate with backup systems needed for Clean Air Act permit compliance – the so-called n+1 redundancy – following the December 24, 2018 incident and would not have had to send untreated, high sulfur COG to be flared at the Irvin plant and combusted in other Mon Valley Works production units.

The excerpt above also references a preventive and predictive maintenance program for rotating equipment (such as the axial compressors, one of which was involved in exacerbating the December 24, 2018 incident). Yet, this program was so inadequate that, only after the December fire occurred, did US Steel begin a process of installing vibration monitoring sensors²⁰ – a very

²⁰ To the extent that periodic vibration monitoring was being conducted prior to the December fire (“...inspection frequency is dependent upon the importance of the equipment to continued operations and the safety and fire protection ramifications assuming failure of the equipment” – see USSP007898), it was performed by a third party (SKF), which is not a substitute for continuous and ongoing vibration monitoring.

basic type of preventive maintenance equipment – on the axial compressors.²¹ It is inappropriate for US Steel to take credit for “predictive” or “reliability centered” maintenance when even the most basic instruments for assessing the condition and operating characteristics of critical equipment are missing.

The excerpt above also mentions the OSHA Process Safety Management (PSM) program and implies that compliance with this program makes a plant safe per se. That is backwards. The PSM program, a generally self-enforcing set of regulations, *relies* on operators being diligent in all aspects of safety and thus assuring that process safety is the result. Thus, relying on the PSM program to suggest that the plant is being safely operated makes no sense – it has the process backwards.

Example 3 – Fire Protection²²

The following excerpt from the Marsh risk evaluation report falls under the category of “Opportunities for Improvement” in the area of “Physical Protection ... to control specific hazards.”

²¹ USSP018706

²² USSP007853

| OFI-2003-01 (Revised 2018) | | Fire Protection Water Supply and Underground Fire Main Improvements | |
|-------------------------------|---|---|---------------|
| Status | In Process | Status Date | July 2018 |
| Priority | Complete Within 36 Months | Type | Major Capital |
| Related RTM ID | RTM-2015-01, RTM-2015-04 | | |
| Description | <p>The project of reviewing the condition of the underground water mains and the sectional control isolation valves should continue throughout the plant. All sections of underground water mains should be evaluated and sections that are determined to be in poor condition should be replaced.</p> <p>With improved water main condition, the jockey pumps should be used to maintain a higher water main pressure closer to the churn pressure of the fire pumps.</p> | | |
| Details | <p>Several underground fire main breaks occur each year and in some instances are attributable in part to the fire pump starts. The existing relief valves on the automatic (or remote starting) U.S. Steel diesel driven fire pumps have been reset to 175 psi (max) to help lessen the effects of these starts.</p> <p>The underground main is being reviewed for deterioration and replacement of major critical sections.</p> | | |
| Client Response | <p>Major sections of the underground water main system are being prioritized based on condition and a replacement plan is being developed. A major capital engineering project is in the process of being reviewed and approved for the replacement of the underground with FM approved HDPE pipe. Detailed plans are in the works with preliminary submittal for approval occurring soon and detailed full plans scheduled to be submitted for approval in October 2018.</p> | | |
| Loss Expectancy (USD) | Property Damage: | Reliability | |
| | Business Interruption: | Reliability | |
| | Estimated Cost to Complete: | \$7,000,000 | |
| | Loss Expectancy After Completion: | Reliability | |

Fire protection is obviously a bedrock in any safety program at a plant, like Clairton, conducting chemical processing operations with highly flammable gases (such as coke oven gas) and liquids (such as lubricating oil). Yet, as the example notes, even though “several ... fire main breaks occur each year,” as of July 2018 (*i.e.*, roughly 6 months prior to the December fire), the overall upgrading of this system was anticipated to take place over 36 months – a considerable length of time for replacement of a critical system – and this capital improvement project had not even been approved yet. Also, it is not clear how the prioritization was conducted to determine which portions to replace and in what order, and whether appropriate factors were properly considered in this prioritization.

Example 4 – Implementation Delays²³

The excerpts below show the considerable delays in implementing corrective actions at the Clairton Control Rooms, even when issues had been identified long prior. Thus, in item [01], a

²³ USSP007857-58

deficient and dangerous condition in the Control Room No. 2 cable basement was noted in May 2015, but had still not been cleared more than three years later (in 2018, when this report was created). This is remarkable and troubling, given the potential fire safety hazard of storing combustibles in the cable basement and how easily that problem could be remedied (i.e., by removing the combustibles). A three-year delay period of inaction is telling. Either US Steel had far greater safety priorities, or it allowed budget constraints to dictate inaction, or it did not care. None of these explanations are confidence builders.

4. Maintenance & Housekeeping Items Requiring Attention

The following items were noted during our evaluation and are not at this time offered as formal OFI as they generally require limited planning for correction and/or were addressed or agreed to be addressed immediately by plant personnel. It is important to note such items as they can reflect symptoms or tendencies.

| | |
|----------------------|---|
| [01] | May 2015 |
| Description | Control Room No. 2 Cable Basement: The caged storage area containing cartons of spare parts and other ordinary combustibles should be removed from the cable basement. This combustible storage presents a fire exposure to the cable trays and can rapidly intensify a fire scenario. Sprinkler protection is provided, but the storage represents an unnecessary exposure to the cable vault of this important control room. |
| Status Update (2018) | This is still the same. |

| | |
|----------------------|--|
| [02] | May 2015 |
| Description | No. 1 Substation: The three Automatic "Suprotex" deluge valves are functionally obsolete and should be considered for replacement. |
| Status Update (2018) | The valve bodies are available on site. The new water main connection to the building is complete. The next phase of the project is to install the new valves when funding is available. |

| | |
|----------------------|--|
| [03] | March 2016 (revised July 2018) |
| Description | Axial Compressor Buildings No. 1 and No. 2 Control Room: The automatic sprinkler heads on the wet pipe sprinkler systems in the lube oil cellars should be reviewed and evaluated. Those heads with corrosion or covered in oil and dusty residue should be cleaned or replaced. Consideration should be given to washing down the walls and sprinkler heads on some frequency. |
| Status Update (2018) | This is to be done. |

Similar delays are noted for items [02] and [03] above. I also note the explicit budget constraint noted for item [02] – "...when funding is available..." – in explaining the lack of action.

Example 5 – Structural Integrity²⁴

Ironically, given the cause(s) of the December fire discussed above, the insurance inspection in July 2018 noted that “[S]tructural integrity continues to be reviewed on a regular basis and repairs made as needed throughout the Clairton Plant.” The document noted that such inspections occur on a weekly and monthly basis.²⁵

The ineffectiveness of such integrity review is belied by the causes of the fire, which reinforces the need for thorough, comprehensive inspections, as opposed to what has previously passed for “inspections” at Clairton. (I note that this issue, with respect to inspections of the roof area and deluge piping and supports, is addressed in far greater detail in the expert report of Michael B. Plunkett submitted in this case.)

Sixth, the somewhat cavalier attitude towards maintenance and repairs as well as the ad-hoc nature of prioritizing maintenance at Clairton are illustrated in the next two excerpts.²⁶ In the first excerpt (email dated February 5, 2019), the author confirms that US Steel does not have any idea as to the extent of corrosion, and yet he is suggesting remedies off-the-cuff: “build bad areas up to what you need, put on a good coat of 2 part epoxy paint...and call it a day.”

Fwd: System One Thickness Readings - Suction Header

From: "Klutschkowski, Michael J" <mklutschkowski@uss.com>
To: "Rhoads, Mike S" <mrhoads@uss.com>; "Zelenski, Steve J" <szelenski@uss.com>
Date: Tue, 05 Feb 2019 23:33:13 +0000
Attachments: (1.10.19) L-500Z-42, L-500M-24, L-500L-24 Sub Gas (CR-2) Call-out Final.pdf (487.14 kB); (1.14.19) Sub Gas Header Offtake Lines (CR-2) Final.pdf (1.3 MB); 2 CR Axi Compressor Inlet Piping Thickness Report 1-29-19.pdf (2.27 MB)

Can't understand why we don't high pressure water blast affected areas so we can see what the hell we are really dealing with. Measure extent/depth of corrosion with a pit gauge and come up with repair plan from there (either pad welding or clad plates depending upon area). Not like you need 3/8" pipe wall thickness to handle vacuum at this level. Build bad areas up to what you need, put on a good coat of 2 part epoxy paint to arrest further external corrosion, and call it a day.

Sent from my iPhone

In the excerpt below, Mr. Barshick, the General Manager of the Mon Valley Works, is asking that items be added to the “Top 25 operational risks.” While this may be appropriate, it does not show any sort of systematic creation of those “Top 25” risks if items can be added (and presumably

²⁴ USSP007861

²⁵ USSP007871

²⁶ USSP015810 and USSP018610, respectively.

subtracted) in the ad-hoc manner indicated by the email – i.e., by direction from upper management.

```
>>> From: Barshick, Kurt A
>>> Sent: Friday, December 28, 2018 11:48 AM
>>> To: Petrilena, Brenda J <bjpgtrilena@uss.com>; Diwanji, Ashish P <APDiwanji@uss.com>;
Rhoads, Mike S <MRhoads@uss.com>; Votodian, Francis M <FMVotodian@uss.com>; Ferchak Jr,
Ron C <RFerchak@uss.com>
>>> Subject: Top 25 Operational Risks
>>>
>>> Brenda-
>>>
>>> We need to add #1&2 Control room fire protection and video/sensor monitoring systems to our
Top 25 operational risks. We will look to modernize our detection systems ASAP in 2019.
>>> I'd say rank it in the top 5. Thanks.
```

Seventh, much of the ad-hoc and haphazard nature of US Steel's maintenance activities at Clairton were confirmed in recent depositions of Mr. Michael Rhodes (Clairton plant manager) and Mr. Mark Jeffrey (the Head of Reliability Centered Maintenance at Mon Valley Plants from 2014-2017). I will provide further analysis and commentary once I have an opportunity to review the actual transcripts.

RECOMMENDATIONS REGARDING DEFICIENT MAINTENANCE AND DESIGN

Based on the evidence available to me at this time, as discussed above, it is my opinion that US Steel's maintenance and operation of the Clairton Control Room areas are substandard by any measure, including US Steel's own stated goals (which Mr. Jeffrey has stated as achieving "best in class" status) and reasonable industry standards of care – much less industry "best practice" standards. This systemic failing interferes substantially with US Steel's ability to comply with its Clean Air Act permits, as evidenced by the violations that are the subject of this lawsuit.

To address this systemic failing, it is my opinion that US Steel needs to commission, or be ordered by a court to submit to, an independent third-party audit of the Clairton Control Rooms. Such an audit is the first, necessary step toward achieving a state of functionality that would enable more consistent compliance with the requirements of its Clean Air Act permits. At a minimum, such an audit should include:

- (a) a thorough assessment of the baseline condition of all equipment in a systematic manner, regardless of accessibility. This should include appropriate inspection and testing of equipment for remaining useful life, as well as for corrosion, stress cracking, and the like;
- (b) a thorough assessment of US Steel's maintenance program as a whole, including staffing, training, competence, procedures, monitoring and testing equipment, outside expertise, available supplies for replacement and repair, and budgeting;

In addition, it is my opinion that design flaws exist in the Clairton systems responsible for maintaining compliance with the Clean Air Act requirements that US Steel is charged with violating in this case. Those design flaws greatly increase the likelihood that, when mechanical

failures or accidents occur in the Control Room areas, the Clairton, Irvin and Edgar Thomson plants will violate the requirements of their Clean Air Act permits.

To address these design flaws, it is my opinion that US Steel needs to commission, or be ordered by a court to submit to, an independent third-party engineering study to present options for addressing the most serious of those flaws. At a minimum, such an engineering study should include:

- (a) an evaluation of the need for redundant systems in the byproducts recovery process, including options for re-design of specific units or equipment. It is clear that the n+1 redundancy goal noted in some of the prior outside reviews is not currently being met;
- (b) an evaluation of options for enhanced or expedited procedures for putting coke ovens on hot idle, or other methods to very rapidly reduce or eliminate COG production, when the Control Rooms are unable to operate;
- (c) an evaluation of options for design and installation of a COG recovery system capable of storing sufficient amounts of untreated COG to enable coke production to continue when the Control Rooms are unable to operate without sending untreated COG to the flares.

VI. COSTS OF MEASURES NEEDED FOR CLEAN AIR ACT COMPLIANCE

In its current condition, the Clairton plant is inherently dangerous because of the combination of its deficient maintenance and its defective design. This section discusses costs that were avoided or delayed by US Steel with regards to maintenance and capital spending items that were needed to avoid the types of breakdowns that have caused incidents such as the December 24, 2018 fire, and the resulting violations of US Steel's Clean Air Act permits.

Due to the complexity and interrelatedness of the deficiencies at the Clairton plant that I have discussed previously – some or all of which could be said to have a role in causing the various incidents and resulting violations – and the incomplete evidence I have as of this writing for the cost of avoided or delayed upgrades needed for compliance with Clean Air Act requirements, the following discussion covers two general categories of needed compliance measures and corresponding cost estimates. I understand that Plaintiffs' counsel will provide these estimates to Jonathan Shefftz, the economist they have retained to analyze the economic benefit of non-compliance for this case.

VI.1 Remediating Deficiencies in Maintenance

I have a limited ability to identify and determine costs for all the types of equipment that failed in contributing to the December 24, 2018 fire – and to other failures that contributed to violations of the same permit requirements at issue here – the July 2018 desulfurization plant outage, the June 2019 fire and outage, and others. And I intentionally refer to *types* of equipment, rather than just the specific pieces that failed on December 24, 2018, in order to avoid falling into the hindsight trap: for example, in order to ensure that compressor C-521 had a properly designed lube oil system and an uncracked rotor shaft and a functioning check valve, US Steel would have needed to have systems in place to ensure that *all* of its compressors and their many component parts were in good repair and able to operate safely, because they did not know ahead of time which one would fail with catastrophic results. Plaintiffs are still in the process of gathering this information – from documents, interrogatories, and depositions. Accordingly, I expect to include additional information that I obtain after this initial report is submitted and I therefore reserve the right to supplement.

VI.1.1 Delayed or Avoided Cost of Specific Equipment, Maintenance Work, and Capital Upgrades

It has been reported that US Steel spent roughly \$35-40 million in the aftermath of the December 24, 2018 fire. It is my opinion that a fair portion of the post-fire expenses characterized as “repair expenses” are, in fact, a concrete measure of delayed compliance expenditures for specific items which could have prevented or lowered the severity of the incident or which, if not addressed thanks to the opportunity created by the fire-caused shutdown, would likely have failed in the near future and resulted in similar types of permit violations. Many of the post-fire expenditures (such as replacing the defective roof and other structural features, replacing corroded valves and piping,

overhauling compressors, overhauling electrical systems, adding instrumentation for monitoring the condition of equipment, etc.) should have been made proactively years earlier. So, much of the repair work reveals evidence of delayed expenditures that were required for compliance.

In the chart below, I list delayed or avoided expenditures on measures I am currently aware of that were necessary for compliance with the various permit requirements at issue in this case (including numerical limits on H₂S and SO₂, and requirements to operate various pollution control systems to control emissions at all times the coke batteries are operating). The list of measures, as well as cost estimates and completion dates for listed measures, may be revised as I obtain additional information. I have used US Steel's assumed annual cost of a full-time equivalent employee (FTE) labor cost of \$100,000 in the analysis, as needed. "When Should Have Spent" is the date the compliance expenditure should have been made (or, in the case of recurring annual costs, should have begun). "When Did or Will Spend" is the date the compliance expenditure was actually made, is anticipated to be made, or the date the expenditure would be required to be made by court order or settlement agreement (I have used January 2022 as a reasonable estimate).

COST OF SPECIFIC MEASURES

| DELAYED/AVOIDED EXPENDITURE | CAPITAL COST (delayed) | O&M COST (avoided) | WHEN SHOULD HAVE SPENT | WHEN DID OR WILL SPEND |
|---|---|-------------------------------|-------------------------------|-------------------------------|
| Replace leaking roof with defective design in Control Room 2 USSP018696; Rhoads Deposition | \$360,000 | | 1999 | 4/2019 |
| Replace deluge piping system using proper materials | \$1,072,000 | | 2003 | 4/2019 |
| Annual inspection of deluge piping and supports Plunkett Report | | 3 FTE x 2 days = \$2,310/yr | 2003 | 1/2022 |
| Improper design of lube oil tripping system | \$35,000 | | 2014 | 4/2019 |
| Add protective shield to lube oil piping for all compressors Plunkett Report | 1 FTE x 2 days = \$770 x [# of compressors] | | 2014 | 1/2022 |
| Rotor shaft in vacuum compressor C-521 | NEED COST TO REPLACE | | | |

| | | | | |
|--|----------------------|--|------|--------|
| Cost of inspecting and replacing check valves | NEED COST TO REPLACE | NEED COST OF INSPECTIONS | | |
| Cost of commissioning comprehensive 3rd-party audit | | NEED COST; or 5 FTE x 2 months (43 work days) = \$82,775 | 2014 | 1/2022 |
| Replace cooling tower water piping in Control Rm 2 USSP018696 | \$1,095,420 | | 2014 | 4/2019 |
| Replacement of 3 heat exchangers and piping USSP018696 | \$772,590 | | 2014 | 4/2019 |
| Replace 250' of sub-sub gas piping for compressors USSP018696 | \$1,100,000 | | 2014 | 4/2019 |
| Treatment plant for cyanide USSP018696 | \$1,883,917 | | 2014 | 4/2019 |
| Add on-site facility for repair/rebuild of axial compressor suction valves USSP018696 | \$1,050,515 | | 2009 | 4/2019 |
| Replace isolation valves and deteriorate tail gas piping USSP018696 | \$160,780 | | 2014 | 4/2019 |
| Re-wire PLC and control room USSP018696 | \$1,000,000 | | 2014 | 4/2019 |
| Vibration detection system for axial compressors USSP018709 | \$2,219,000 | | 1997 | 1/2021 |
| Install 5 KV Switch gear in Control Rm 1 | \$4,000,000 | | 2014 | 1/2021 |
| Install redundant axial compressor in Control Rm 5 | NEED COST | | 1997 | |
| Enhanced electrical system testing | NEED COST | NEED COST | 2009 | |
| | | | | |

IV.1.2 Avoided Cost of a Sufficient Preventive Maintenance Program

In addition to the specific items identified in the previous section, US Steel would have needed to incur added labor and material costs for an enhanced inspection, repair & replacement program in order to generate the *proactive* implementation of the delayed expenditures described in the chart above. However, it is difficult if not impossible to come up with a concrete estimate of that amount, for the following reasons.

First, it is my understanding that Clairton plant manager Michael Rhoads testified that he does not know what the “maintenance budget” for the Control Rooms is, because US Steel does not have a separate budget category for maintenance. So there is no actual spending amount to use for comparison to what should have been spent.

Second, estimating the cost of a robust preventive maintenance program for a specific facility, as an outside observer, is necessarily imprecise. I can, however, provide an order-of-magnitude range for what US Steel should be spending on maintenance for the Control Room areas of the plant. As a rule of thumb used²⁷ the typical cost for a preventive maintenance program (not including capital replacement items) in a chemical plant ranges from approximately 2% to 5% of the replacement cost of the plant (as noted earlier, each of the Control Rooms is a chemical processing unit). One could perform such a calculation as follows: the capital cost to build a new by-products coke plant (like Clairton) in the 1990s was around \$350 per annual ton of production. An inflation adjustment would then be used to adjust that figure (a multiplier of around 1.6 would likely be appropriate, assuming roughly 2% annual inflation in that time period). The estimated replacement cost for the Clairton plant as a whole would thus be $\$350 * 1.6 * 4.3$ million, or roughly \$2.5 billion. Assuming the by-products recovery portion of this plant would constitute roughly 40% of the total capital cost, estimated annual maintenance spending for the by-products portion of the plant would be $\$2.5 \text{ billion} * 0.4 * (2\% - 5\%)$, or \$20 to \$50 million per year. Given the age of the plant, maintenance spending should be at the higher end of the range (\$40 – \$50 million/year) for at least several years, before all back-logged deferred maintenance items have been cleared, and with capital improvement projects implemented as needed.

Even though this is a rough calculation, it nonetheless provides a basis for concluding that US Steel should be spending tens of millions of dollars annually on its maintenance programs for the Control Rooms. That it has been underspending, by some amount, on what is required is demonstrated by the analysis in Sections IV and V above.

VI.2 Remediating Design Flaws

Another major element of US Steel’s avoided compliance costs is the delayed cost of capital expenditures needed to provide backup pollution controls – i.e., backup or redundant means of cleaning the COG should there be any failures in the Control Rooms. Such redundant systems are

²⁷ See, for example, <https://accendoreliability.com/cost-maintenance-destroys-capital-investment-returns/>

necessary because US Steel claims that it is not possible to shut down the coke ovens to stop the generation of COG. In the Clairton plant's present configuration, there is no redundancy in by-product recovery systems sufficient to prevent vast amounts of COG from being sent, untreated, to be combusted in process units or flares, thereby emitting considerable quantities of air pollutants and causing resulting violations of permit limits and air quality standards and adverse health impacts. Changing the design of the plant to provide COG treatment redundancy, or to provide storage of the untreated COG until it can be treated, or to provide for expedited hot idling of the coke oven batteries, or some combination of these, could prevent the combustion of untreated COG that necessarily results in violation of CAA permits.

However, while conceptually valid, assigning a proper cost figure to such potential plant redesigns is not possible without additional data. To the extent that type of information will become available in ongoing discovery, I will supplement this opinion.

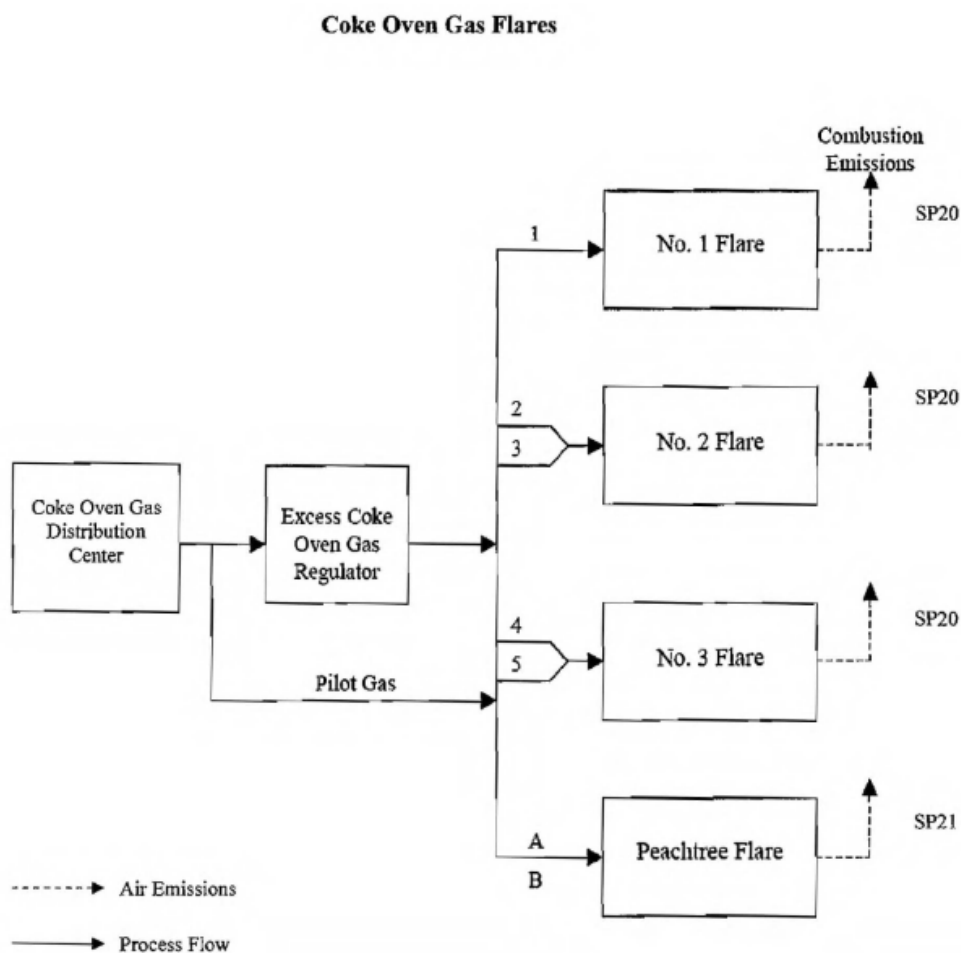
VII. FLARING AND EMISSIONS

As noted previously, COG from Clairton that cannot be treated (i.e., from which contaminants cannot be removed) due to problems in its various Control Rooms is sent downriver and can be flared at one of several flares at the Irvin plant.

VII.1 The Flares at the Irvin Plant

There are four flares at the Irvin plant. Three flares (called or denoted as #1, #2 and #3) are located in a stockade in the south yard of the Irvin plant itself and the fourth, called the Peachtree flare, is located on a hill at the north side of the Irvin plant.²⁸

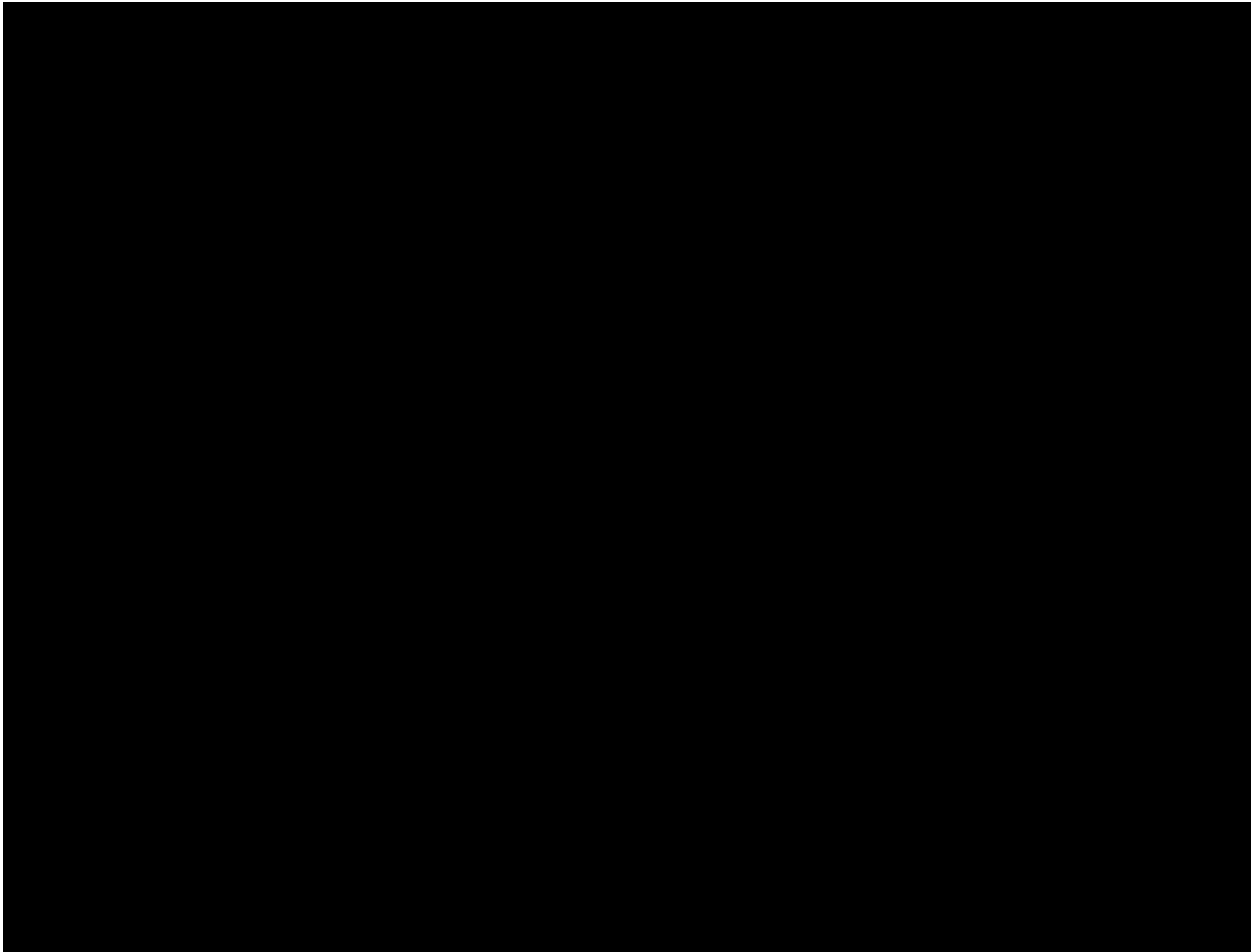
The schematic below shows the process flow diagrams for the flares.²⁹



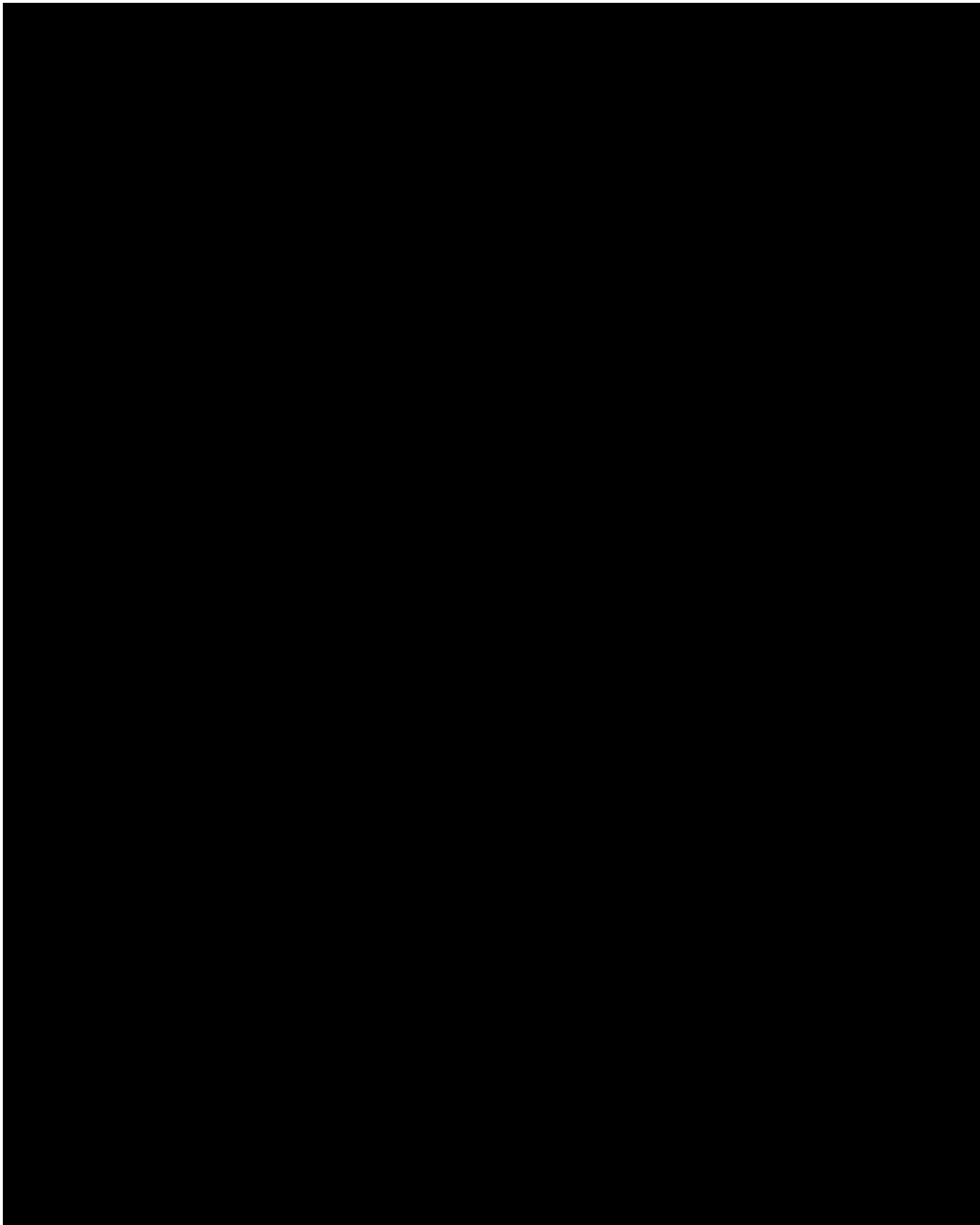
²⁸ USSP019718

²⁹ USSP010018

The photograph below shows the Peachtree flare. As shown in the photograph, it is a stack flare. That means that when it is used, the flame at the top is subject to ambient conditions such as cross-winds.



The photograph below shows two of the three flares #1-#3 at Irvin through the stockade fence surrounding the flares. While the photograph does not show this clearly, each of these three flares has multiple outlets. Functionally, they are also stack flares, except with relatively low elevation as compared to the Peachtree flare. The flames for these three flares are also subject to ambient conditions, such as cross-winds.



During the 100+ days following the December 24, 2018 fire incident at Clairton when the No. 2 and No. 5 Control Rooms were offline, significant amounts of untreated COG were flared at the Irvin plant flares. US Steel documents³⁰ before and after the December 24, 2018 incident show that around 7.01 million cubic feet per day (MMcfd) of COG were flared before the event and this increased to 112 MMcfd in the days after the event – i.e., an increase of 16 times. Further, as discussed previously, without the cleaning capabilities of the No. 2 and No. 5 Control Rooms at Clairton as a result of the fire, the quality of the COG flared at the Irvin flares was significantly worse after the event than before – i.e., it contained far more sulfur and other contaminants. Thus,

³⁰ USSP016046-6047

far greater quantities of COG, of far worse quality, were flared at the Irvin flares for months until the repairs at No. 2 Control Room were completed in mid-2019.

VII.2 Types of Contaminants Emitted by Flares

The flares are simple combustion devices in which the combustible constituents (i.e., hydrocarbons, volatile organic compounds (VOC), sulfur compounds, etc.) in the gases to be flared are simply burned or oxidized using oxygen from ambient air. And, given the rudimentary and simple design of the flares as noted earlier, this combustion process is not particularly efficient in destroying these combustible constituents. I will discuss this destruction efficiency below.

In addition, like all combustion processes, and especially the open stack flames in these flares, a range of so-called products of incomplete combustion (PICs) are also formed to varying degrees. These include carbon monoxide, many other VOC and semi-VOC pollutants, including hazardous air pollutants (HAPs). Finally, flares produce oxides of nitrogen (NO_x) and various sizes of particulate matter (PM) or soot. US Steel has confirmed some but not all of these types of emissions from the flares, as follows:

“8. Identification of Emissions:

A. Type(s) (CO, NO_x, SO₂, Particulates, Hydrocarbons, etc.)

Elevated H₂S in the downriver gas line systems, with potential increases of SO₂, VOCs, and total reduced sulfur. The breakdown may also cause increases of emissions at coke oven gas combustion sources at Irvin and ET, in addition to Clairton. Clairton combustion stack emission particulate may potentially be elevated beyond those occurring during normal operations.

B. Toxic qualities of each type (including its qualities as an irritant, and its potential for causing illness, disability, or mortality). SO₂ is and VOC could be an eye, nose, and throat irritant.”³¹

While US Steel mentions uncombusted H₂S and total reduced sulfur present in the flare gases (i.e., acknowledging incomplete combustion of these compounds), SO₂ (the result of combustion of various sulfur compounds, including H₂S), and VOCs, US Steel does not mention NO_x, various forms of PM or any specific HAPs in its notification to the ACHD after the fire. Yet, the fact that these are all formed in flares is well known.³²

Combustible compounds in flare gases or “reactants,” such as sulfur compounds and hydrocarbons, are oxidized and thereby “destroyed” or converted to “products” such as sulfur dioxide (SO₂) in the case of sulfur compounds and to CO₂, water vapor, and a range of PICs in the

³¹ USSP000496. December 31, 2018 Letter from USS to ACHD.

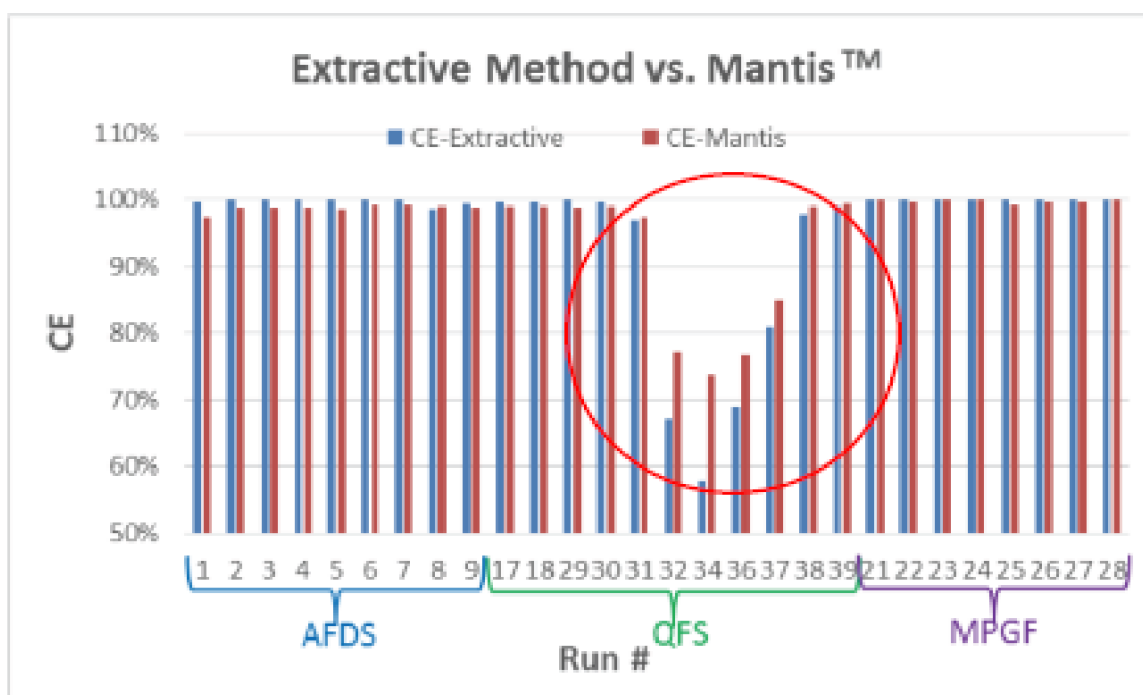
³² See, for example, AP-42 Section 13.5 on flares available at <https://www3.epa.gov/ttnchie1/ap42/ch13/final/c13s05.pdf>. See also, AP-42 Section 1.4 on natural gas combustion available at <https://www3.epa.gov/ttnchie1/ap42/ch01/final/c01s04.pdf>.

The AP-42 Section on Natural Gas combustion shows the emissions of numerous HAPs in addition to NO_x and PM from even this relatively clean fuel source. I provide these references to AP-42 not for the purpose of accurate quantification of these various pollutants from flares but to simply illustrate that a wide range of air pollutants are generated during flaring.

case of hydrocarbons. This happens in any combustion process and not just in flares. But it does happen in flares.

It is well known that flare destruction efficiency (DE)³³, i.e., the fraction of the mass of the reactant constituents in the flare gases that is converted to products, depends on many factors which cannot be controlled in actual operating conditions, especially in the types of stack flares used at Irvin. These factors include but are not limited to: the varying quantity of gases being flared vis-à-vis the design of the flares; the varying compositions of the flare gases (i.e., the varying levels of contaminants in the flare gases); the varying temperature of the flare gases; the varying ambient conditions, including wind-speed and turbulence, at the flare; the ambient temperature and pressure; ambient precipitation; and many other variables. See for example, a technical review of flare emissions prepared by EPA.³⁴

Even when flares have been tested under ideal conditions, their DE and CE can vary widely. The chart below is excerpted from some controlled testing done on flares to compare CE using two techniques – extractive sampling and Video Imaging Spectral Radiometry (VISR), using a product called MANTIS.³⁵



³³ In combustion literature a different term, combustion efficiency (CE), is used for hydrocarbons. It represents the conversion of the hydrocarbons in the flare to CO₂ and water vapor – i.e., the degree of complete combustion.

³⁴ <https://www3.epa.gov/airtoxics/flare/2012flaretechreport.pdf>

³⁵ <https://www.providencephotonics.com/events>

As the chart shows, CE (and DE, which closely tracks CE), even under controlled conditions, can drop from high values to very low values (55% or so in this case). So, simply assuming that destruction efficiency levels will always be 98% or 99%, as is common, is not realistic and the evidence establishes that achieving such rates is not feasible or not consistently achievable. This is especially true of stack flares like the ones at Irvin. Under cross-wind conditions, the CE and DE can drop much lower than even the 55% that is shown in this example. It is not uncommon for stack flares to be quenched or come close to being quenched – i.e., exhibiting DE approaching zero under combinations of ambient and flare composition conditions.

Compounding the problem, stack flares are difficult to test using conventional means due to safety reasons. Crucially, the assumed destruction efficiency makes a large impact on the estimated emissions from flares. Consider, as an example, a flare whose VOC emissions have been estimated to be 100 pounds/hour using a DE of 99%. If that flare achieved not 99% but just 98% DE, its emissions would *double* to 200 pounds/hour. If the DE dropped to 95%, the VOC emissions would rise to 500 pounds/hour, or five times more than if the DE were 99%. This is simply how the math works.

Since there is no reason to believe, based on actual flare monitoring data noted above, that even well designed and well operated flares can achieve 98/99% DE under all circumstances; and since actual DE's can be far lower, it is clear that VOC (and associated HAP) emissions from flaring at Irvin during the 100+ days after the December fire likely were considerably higher than that estimated by US Steel. For untreated COG, heightened emissions of VOCs would include benzene (a human carcinogen), toluene and xylene. Similarly, failure to achieve high DE for H₂S and other sulfur compounds in the COG flared at Irvin means it is likely that far greater amounts of hydrogen sulfide were emitted from the flares than US Steel has acknowledged.

ATTACHMENT A – RESUME AND STATEMENT OF QUALIFICATIONS

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EXPERIENCE SUMMARY

Dr. Sahu has over thirty years of experience in the fields of environmental, mechanical, and chemical engineering including: program and project management services; design and specification of pollution control equipment for a wide range of emissions sources including stationary and mobile sources; soils and groundwater remediation including landfills as remedy; combustion engineering evaluations; energy studies; multimedia environmental regulatory compliance (involving statutes and regulations such as the Federal CAA and its Amendments, Clean Water Act, TSCA, RCRA, CERCLA, SARA, OSHA, NEPA as well as various related state statutes); transportation air quality impact analysis; multimedia compliance audits; multimedia permitting (including air quality NSR/PSD permitting, Title V permitting, NPDES permitting for industrial and storm water discharges, RCRA permitting, etc.), multimedia/multi-pathway human health risk assessments for toxics; air dispersion modeling; and regulatory strategy development and support including negotiation of consent agreements and orders.

He has over twenty seven years of project management experience and has successfully managed and executed numerous projects in this time period. This includes basic and applied research projects, design projects, regulatory compliance projects, permitting projects, energy studies, risk assessment projects, and projects involving the communication of environmental data and information to the public.

He has provided consulting services to numerous private sector, public sector and public interest group clients. His major clients over the past twenty five years include various trade associations as well as individual companies such as steel mills, petroleum refineries, cement manufacturers, aerospace companies, power generation facilities, lawn and garden equipment manufacturers, spa manufacturers, chemical distribution facilities, and various entities in the public sector including EPA, the US Dept. of Justice, several states, various agencies such as the California DTSC, various municipalities, etc.). Dr. Sahu has performed projects in all 50 states, numerous local jurisdictions and internationally.

In addition to consulting, for approximately twenty years, Dr. Sahu taught numerous courses in several Southern California universities including UCLA (air pollution), UC Riverside (air pollution, process hazard analysis), and Loyola Marymount University (air pollution, risk assessment, hazardous waste management). He also taught at Caltech, his alma mater (various engineering courses), at the University of Southern California (air pollution controls) and at California State University, Fullerton (transportation and air quality).

Dr. Sahu has and continues to provide expert witness services in a number of environmental areas discussed above in both state and Federal courts as well as before administrative bodies (please see Attachment D).

EXPERIENCE RECORD

2000-present **Independent Consultant.** Providing a variety of private sector (industrial companies, land development companies, law firms, etc.), public sector (such as the US Department of Justice), and public interest group clients with project management, environmental consulting, project management, as well as regulatory and engineering support consulting services.

- 1995-2000 Parsons ES, **Associate, Senior Project Manager and Department Manager for Air Quality/Geosciences/Hazardous Waste Groups**, Pasadena. Responsible for the management of a group of approximately 24 air quality and environmental professionals, 15 geoscience, and 10 hazardous waste professionals providing full-service consulting, project management, regulatory compliance and A/E design assistance in all areas.
- Parsons ES, **Manager for Air Source Testing Services**. Responsible for the management of 8 individuals in the area of air source testing and air regulatory permitting projects located in Bakersfield, California.
- 1992-1995 Engineering-Science, Inc. **Principal Engineer and Senior Project Manager** in the air quality department. Responsibilities included multimedia regulatory compliance and permitting (including hazardous and nuclear materials), air pollution engineering (emissions from stationary and mobile sources, control of criteria and air toxics, dispersion modeling, risk assessment, visibility analysis, odor analysis), supervisory functions and project management.
- 1990-1992 Engineering-Science, Inc. **Principal Engineer and Project Manager** in the air quality department. Responsibilities included permitting, tracking regulatory issues, technical analysis, and supervisory functions on numerous air, water, and hazardous waste projects. Responsibilities also include client and agency interfacing, project cost and schedule control, and reporting to internal and external upper management regarding project status.
- 1989-1990 Kinetics Technology International, Corp. **Development Engineer**. Involved in thermal engineering R&D and project work related to low-NO_x ceramic radiant burners, fired heater NO_x reduction, SCR design, and fired heater retrofitting.
- 1988-1989 Heat Transfer Research, Inc. **Research Engineer**. Involved in the design of fired heaters, heat exchangers, air coolers, and other non-fired equipment. Also did research in the area of heat exchanger tube vibrations.

EDUCATION

- 1984-1988 Ph.D., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.
- 1984 M. S., Mechanical Engineering, California Institute of Technology (Caltech), Pasadena, CA.
- 1978-1983 B. Tech (Honors), Mechanical Engineering, Indian Institute of Technology (IIT) Kharagpur, India

TEACHING EXPERIENCE

Caltech

- "Thermodynamics," Teaching Assistant, California Institute of Technology, 1983, 1987.
- "Air Pollution Control," Teaching Assistant, California Institute of Technology, 1985.
- "Caltech Secondary and High School Saturday Program," - taught various mathematics (algebra through calculus) and science (physics and chemistry) courses to high school students, 1983-1989.
- "Heat Transfer," - taught this course in the Fall and Winter terms of 1994-1995 in the Division of Engineering and Applied Science.
- "Thermodynamics and Heat Transfer," Fall and Winter Terms of 1996-1997.

U.C. Riverside, Extension

- "Toxic and Hazardous Air Contaminants," University of California Extension Program, Riverside, California. Various years since 1992.
- "Prevention and Management of Accidental Air Emissions," University of California Extension Program, Riverside, California. Various years since 1992.

"Air Pollution Control Systems and Strategies," University of California Extension Program, Riverside, California, Summer 1992-93, Summer 1993-1994.

"Air Pollution Calculations," University of California Extension Program, Riverside, California, Fall 1993-94, Winter 1993-94, Fall 1994-95.

"Process Safety Management," University of California Extension Program, Riverside, California. Various years since 1992-2010.

"Process Safety Management," University of California Extension Program, Riverside, California, at SCAQMD, Spring 1993-94.

"Advanced Hazard Analysis - A Special Course for LEPCs," University of California Extension Program, Riverside, California, taught at San Diego, California, Spring 1993-1994.

"Advanced Hazardous Waste Management" University of California Extension Program, Riverside, California. 2005.

Loyola Marymount University

"Fundamentals of Air Pollution - Regulations, Controls and Engineering," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1993.

"Air Pollution Control," Loyola Marymount University, Dept. of Civil Engineering, Fall 1994.

"Environmental Risk Assessment," Loyola Marymount University, Dept. of Civil Engineering. Various years since 1998.

"Hazardous Waste Remediation" Loyola Marymount University, Dept. of Civil Engineering. Various years since 2006.

University of Southern California

"Air Pollution Controls," University of Southern California, Dept. of Civil Engineering, Fall 1993, Fall 1994.

"Air Pollution Fundamentals," University of Southern California, Dept. of Civil Engineering, Winter 1994.

University of California, Los Angeles

"Air Pollution Fundamentals," University of California, Los Angeles, Dept. of Civil and Environmental Engineering, Spring 1994, Spring 1999, Spring 2000, Spring 2003, Spring 2006, Spring 2007, Spring 2008, Spring 2009.

International Programs

"Environmental Planning and Management," 5 week program for visiting Chinese delegation, 1994.

"Environmental Planning and Management," 1 day program for visiting Russian delegation, 1995.

"Air Pollution Planning and Management," IEP, UCR, Spring 1996.

"Environmental Issues and Air Pollution," IEP, UCR, October 1996.

PROFESSIONAL AFFILIATIONS AND HONORS

President of India Gold Medal, IIT Kharagpur, India, 1983.

Member of the Alternatives Assessment Committee of the Grand Canyon Visibility Transport Commission, established by the Clean Air Act Amendments of 1990, 1992.

American Society of Mechanical Engineers: Los Angeles Section Executive Committee, Heat Transfer Division, and Fuels and Combustion Technology Division, 1987-mid-1990s.

Air and Waste Management Association, West Coast Section, 1989-mid-2000s.

PROFESSIONAL CERTIFICATIONS

EIT, California (#XE088305), 1993.

REA I, California (#07438), 2000.

Certified Permitting Professional, South Coast AQMD (#C8320), since 1993.

QEP, Institute of Professional Environmental Practice, since 2000.

CEM, State of Nevada (#EM-1699). Expiration 10/07/2021.

ATTACHMENT B – LIST OF PUBLICATIONS

PUBLICATIONS (PARTIAL LIST)

- "Physical Properties and Oxidation Rates of Chars from Bituminous Coals," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **67**, 275-283 (1988).
- "Char Combustion: Measurement and Analysis of Particle Temperature Histories," with R.C. Flagan, G.R. Gavalas and P.S. Northrop, *Comb. Sci. Tech.* **60**, 215-230 (1988).
- "On the Combustion of Bituminous Coal Chars," PhD Thesis, California Institute of Technology (1988).
- "Optical Pyrometry: A Powerful Tool for Coal Combustion Diagnostics," *J. Coal Quality*, **8**, 17-22 (1989).
- "Post-Ignition Transients in the Combustion of Single Char Particles," with Y.A. Levendis, R.C. Flagan and G.R. Gavalas, *Fuel*, **68**, 849-855 (1989).
- "A Model for Single Particle Combustion of Bituminous Coal Char." Proc. ASME National Heat Transfer Conference, Philadelphia, **HTD-Vol. 106**, 505-513 (1989).
- "Discrete Simulation of Cenospheric Coal-Char Combustion," with R.C. Flagan and G.R. Gavalas, *Combust. Flame*, **77**, 337-346 (1989).
- "Particle Measurements in Coal Combustion," with R.C. Flagan, in "**Combustion Measurements**" (ed. N. Chigier), Hemisphere Publishing Corp. (1991).
- "Cross Linking in Pore Structures and Its Effect on Reactivity," with G.R. Gavalas in preparation.
- "Natural Frequencies and Mode Shapes of Straight Tubes," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).
- "Optimal Tube Layouts for Kamui SL-Series Exchangers," with K. Ishihara, Proprietary Report for Kamui Company Limited, Tokyo, Japan (1990).
- "HTRI Process Heater Conceptual Design," Proprietary Report for Heat Transfer Research Institute, Alhambra, CA (1990).
- "Asymptotic Theory of Transonic Wind Tunnel Wall Interference," with N.D. Malmuth and others, Arnold Engineering Development Center, Air Force Systems Command, USAF (1990).
- "Gas Radiation in a Fired Heater Convection Section," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1990).
- "Heat Transfer and Pressure Drop in NTIW Heat Exchangers," Proprietary Report for Heat Transfer Research Institute, College Station, TX (1991).
- "NOx Control and Thermal Design," Thermal Engineering Tech Briefs, (1994).
- "From Purchase of Landmark Environmental Insurance to Remediation: Case Study in Henderson, Nevada," with Robin E. Bain and Jill Quillin, presented at the AQMA Annual Meeting, Florida, 2001.
- "The Jones Act Contribution to Global Warming, Acid Rain and Toxic Air Contaminants," with Charles W. Botsford, presented at the AQMA Annual Meeting, Florida, 2001.

PRESENTATIONS (PARTIAL LIST)

- "Pore Structure and Combustion Kinetics - Interpretation of Single Particle Temperature-Time Histories," with P.S. Northrop, R.C. Flagan and G.R. Gavalas, presented at the AIChE Annual Meeting, New York (1987).
- "Measurement of Temperature-Time Histories of Burning Single Coal Char Particles," with R.C. Flagan, presented at the American Flame Research Committee Fall International Symposium, Pittsburgh, (1988).

"Physical Characterization of a Cenospheric Coal Char Burned at High Temperatures," with R.C. Flagan and G.R. Gavalas, presented at the Fall Meeting of the Western States Section of the Combustion Institute, Laguna Beach, California (1988).

"Control of Nitrogen Oxide Emissions in Gas Fired Heaters - The Retrofit Experience," with G. P. Croce and R. Patel, presented at the International Conference on Environmental Control of Combustion Processes (Jointly sponsored by the American Flame Research Committee and the Japan Flame Research Committee), Honolulu, Hawaii (1991).

"Air Toxics - Past, Present and the Future," presented at the Joint AIChE/AAEE Breakfast Meeting at the AIChE 1991 Annual Meeting, Los Angeles, California, November 17-22 (1991).

"Air Toxics Emissions and Risk Impacts from Automobiles Using Reformulated Gasolines," presented at the Third Annual Current Issues in Air Toxics Conference, Sacramento, California, November 9-10 (1992).

"Air Toxics from Mobile Sources," presented at the Environmental Health Sciences (ESE) Seminar Series, UCLA, Los Angeles, California, November 12, (1992).

"Kilns, Ovens, and Dryers - Present and Future," presented at the Gas Company Air Quality Permit Assistance Seminar, Industry Hills Sheraton, California, November 20, (1992).

"The Design and Implementation of Vehicle Scrapping Programs," presented at the 86th Annual Meeting of the Air and Waste Management Association, Denver, Colorado, June 12, 1993.

"Air Quality Planning and Control in Beijing, China," presented at the 87th Annual Meeting of the Air and Waste Management Association, Cincinnati, Ohio, June 19-24, 1994.

ATTACHMENT C – STATEMENT OF COMPENSATION

My compensation for expert witness services to the Plaintiffs for this case is \$200.00 per hour.
My compensation for time spent at depositions and at trial is \$275.00 per hour.

ATTACHMENT D – PRIOR EXPERT EXPERIENCE

A. Occasions where Dr. Sahu has provided Written or Oral testimony before Congress:

1. In July 2012, provided expert written and oral testimony to the House Subcommittee on Energy and the Environment, Committee on Science, Space, and Technology at a Hearing entitled “Hitting the Ethanol Blend Wall – Examining the Science on E15.”

B. Matters for which Dr. Sahu has provided affidavits and expert reports include:

2. Affidavit for Rocky Mountain Steel Mills, Inc. located in Pueblo Colorado – dealing with the technical uncertainties associated with night-time opacity measurements in general and at this steel mini-mill.
3. Expert reports and depositions (2/28/2002 and 3/1/2002; 12/2/2003 and 12/3/2003; 5/24/2004) on behalf of the United States in connection with the Ohio Edison NSR Cases. *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).
4. Expert reports and depositions (5/23/2002 and 5/24/2002) on behalf of the United States in connection with the Illinois Power NSR Case. *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).
5. Expert reports and depositions (11/25/2002 and 11/26/2002) on behalf of the United States in connection with the Duke Power NSR Case. *United States, et al. v. Duke Energy Corp.*, 1:00-CV-1262 (Middle District of North Carolina).
6. Expert reports and depositions (10/6/2004 and 10/7/2004; 7/10/2006) on behalf of the United States in connection with the American Electric Power NSR Cases. *United States, et al. v. American Electric Power Service Corp., et al.*, C2-99-1182, C2-99-1250 (Southern District of Ohio).
7. Affidavit (March 2005) on behalf of the Minnesota Center for Environmental Advocacy and others in the matter of the Application of Heron Lake BioEnergy LLC to construct and operate an ethanol production facility – submitted to the Minnesota Pollution Control Agency.
8. Expert Report and Deposition (10/31/2005 and 11/1/2005) on behalf of the United States in connection with the East Kentucky Power Cooperative NSR Case. *United States v. East Kentucky Power Cooperative, Inc.*, 5:04-cv-00034-KSF (Eastern District of Kentucky).
9. Affidavits and deposition on behalf of Basic Management Inc. (BMI) Companies in connection with the BMI vs. USA remediation cost recovery Case.
10. Expert Report on behalf of Penn Future and others in the Cambria Coke plant permit challenge in Pennsylvania.
11. Expert Report on behalf of the Appalachian Center for the Economy and the Environment and others in the Western Greenbrier permit challenge in West Virginia.
12. Expert Report, deposition (via telephone on January 26, 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women’s Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) in the Thompson River Cogeneration LLC Permit No. 3175-04 challenge.
13. Expert Report and deposition (2/2/07) on behalf of the Texas Clean Air Cities Coalition at the Texas State Office of Administrative Hearings (SOAH) in the matter of the permit challenges to TXU Project Apollo’s eight new proposed PRB-fired PC boilers located at seven TX sites.
14. Expert Testimony (July 2007) on behalf of the Izaak Walton League of America and others in connection with the acquisition of power by Xcel Energy from the proposed Gascoyne Power Plant – at the State of Minnesota, Office of Administrative Hearings for the Minnesota PUC (MPUC No. E002/CN-06-1518; OAH No. 12-2500-17857-2).

15. Affidavit (July 2007) Comments on the Big Cajun I Draft Permit on behalf of the Sierra Club – submitted to the Louisiana DEQ.
16. Expert Report and Deposition (12/13/2007) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (Western District of Pennsylvania).
17. Expert Reports and Pre-filed Testimony before the Utah Air Quality Board on behalf of Sierra Club in the Sevier Power Plant permit challenge.
18. Expert Report and Deposition (October 2007) on behalf of MTD Products Inc., in connection with *General Power Products, LLC v MTD Products Inc.*, 1:06 CVA 0143 (Southern District of Ohio, Western Division) .
19. Expert Report and Deposition (June 2008) on behalf of Sierra Club and others in the matter of permit challenges (Title V: 28.0801-29 and PSD: 28.0803-PSD) for the Big Stone II unit, proposed to be located near Milbank, South Dakota.
20. Expert Reports, Affidavit, and Deposition (August 15, 2008) on behalf of Earthjustice in the matter of air permit challenge (CT-4631) for the Basin Electric Dry Fork station, under construction near Gillette, Wyoming before the Environmental Quality Council of the State of Wyoming.
21. Affidavits (May 2010/June 2010 in the Office of Administrative Hearings)/Declaration and Expert Report (November 2009 in the Office of Administrative Hearings) on behalf of NRDC and the Southern Environmental Law Center in the matter of the air permit challenge for Duke Cliffside Unit 6. Office of Administrative Hearing Matters 08 EHR 0771, 0835 and 0836 and 09 HER 3102, 3174, and 3176 (consolidated).
22. Declaration (August 2008), Expert Report (January 2009), and Declaration (May 2009) on behalf of Southern Alliance for Clean Energy in the matter of the air permit challenge for Duke Cliffside Unit 6. *Southern Alliance for Clean Energy et al., v. Duke Energy Carolinas, LLC*, Case No. 1:08-cv-00318-LHT-DLH (Western District of North Carolina, Asheville Division).
23. Declaration (August 2008) on behalf of the Sierra Club in the matter of Dominion Wise County plant MACT.us
24. Expert Report (June 2008) on behalf of Sierra Club for the Green Energy Resource Recovery Project, MACT Analysis.
25. Expert Report (February 2009) on behalf of Sierra Club and the Environmental Integrity Project in the matter of the air permit challenge for NRG Limestone’s proposed Unit 3 in Texas.
26. Expert Report (June 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*
27. Expert Report (August 2009) on behalf of Sierra Club and the Southern Environmental Law Center in the matter of the air permit challenge for Santee Cooper’s proposed Pee Dee plant in South Carolina).
28. Statements (May 2008 and September 2009) on behalf of the Minnesota Center for Environmental Advocacy to the Minnesota Pollution Control Agency in the matter of the Minnesota Haze State Implementation Plans.
29. Expert Report (August 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
30. Expert Report and Rebuttal Report (September 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.
31. Expert Report (December 2009) and Rebuttal reports (May 2010 and June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).

32. Pre-filed Testimony (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
33. Pre-filed Testimony (July 2010) and Written Rebuttal Testimony (August 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.
34. Expert Report (August 2010) and Rebuttal Expert Report (October 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Liability Phase.
35. Declaration (August 2010), Reply Declaration (November 2010), Expert Report (April 2011), Supplemental and Rebuttal Expert Report (July 2011) on behalf of the United States in the matter of DTE Energy Company and Detroit Edison Company (Monroe Unit 2). *United States of America v. DTE Energy Company and Detroit Edison Company*, Civil Action No. 2:10-cv-13101-BAF-RSW (Eastern District of Michigan).
36. Expert Report and Deposition (August 2010) as well as Affidavit (September 2010) on behalf of Kentucky Waterways Alliance, Sierra Club, and Valley Watch in the matter of challenges to the NPDES permit issued for the Trimble County power plant by the Kentucky Energy and Environment Cabinet to Louisville Gas and Electric, File No. DOW-41106-047.
37. Expert Report (August 2010), Rebuttal Expert Report (September 2010), Supplemental Expert Report (September 2011), and Declaration (November 2011) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)’s Cherokee power plant. No. 09-cv-1862 (District of Colorado).
38. Written Direct Expert Testimony (August 2010) and Affidavit (February 2012) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
39. Deposition (August 2010) on behalf of Environmental Defense, in the matter of the remanded permit challenge to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
40. Expert Report, Supplemental/Rebuttal Expert Report, and Declarations (October 2010, November 2010, September 2012) on behalf of New Mexico Environment Department (Plaintiff-Intervenor), Grand Canyon Trust and Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. Public Service Company of New Mexico* (PNM), Civil No. 1:02-CV-0552 BB/ATC (ACE) (District of New Mexico).
41. Expert Report (October 2010) and Rebuttal Expert Report (November 2010) (BART Determinations for PSCo Hayden and CSU Martin Drake units) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
42. Expert Report (November 2010) (BART Determinations for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) to the Colorado Air Quality Commission on behalf of Coalition of Environmental Organizations.
43. Declaration (November 2010) on behalf of the Sierra Club in connection with the Martin Lake Station Units 1, 2, and 3. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Case No. 5:10-cv-00156-DF-CMC (Eastern District of Texas, Texarkana Division).
44. Pre-Filed Testimony (January 2011) and Declaration (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
45. Declaration (February 2011) in the matter of the Draft Title V Permit for RRI Energy MidAtlantic Power Holdings LLC Shawville Generating Station (Pennsylvania), ID No. 17-00001 on behalf of the Sierra Club.

46. Expert Report (March 2011), Rebuttal Expert Report (June 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).
47. Declaration (April 2011) and Expert Report (July 16, 2012) in the matter of the Lower Colorado River Authority (LCRA)'s Fayette (Sam Seymour) Power Plant on behalf of the Texas Campaign for the Environment. *Texas Campaign for the Environment v. Lower Colorado River Authority*, Civil Action No. 4:11-cv-00791 (Southern District of Texas, Houston Division).
48. Declaration (June 2011) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
49. Expert Report (June 2011) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).
50. Declaration (August 2011) in the matter of the Sandy Creek Energy Associates L.P. Sandy Creek Power Plant on behalf of Sierra Club and Public Citizen. *Sierra Club, Inc. and Public Citizen, Inc. v. Sandy Creek Energy Associates, L.P.*, Civil Action No. A-08-CA-648-LY (Western District of Texas, Austin Division).
51. Expert Report (October 2011) on behalf of the Defendants in the matter of *John Quiles and Jeanette Quiles et al. v. Bradford-White Corporation, MTD Products, Inc., Kohler Co., et al.*, Case No. 3:10-cv-747 (TJM/DEP) (Northern District of New York).
52. Declaration (October 2011) on behalf of the Plaintiffs in the matter of *American Nurses Association et al. (Plaintiffs), v. US EPA (Defendant)*, Case No. 1:08-cv-02198-RMC (US District Court for the District of Columbia).
53. Declaration (February 2012) and Second Declaration (February 2012) in the matter of *Washington Environmental Council and Sierra Club Washington State Chapter v. Washington State Department of Ecology and Western States Petroleum Association*, Case No. 11-417-MJP (Western District of Washington).
54. Expert Report (March 2012) and Supplemental Expert Report (November 2013) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.*, Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).
55. Declaration (March 2012) in the matter of *Center for Biological Diversity, et al. v. United States Environmental Protection Agency*, Case No. 11-1101 (consolidated with 11-1285, 11-1328 and 11-1336) (US Court of Appeals for the District of Columbia Circuit).
56. Declaration (March 2012) in the matter of *Sierra Club v. The Kansas Department of Health and Environment*, Case No. 11-105,493-AS (Holcomb power plant) (Supreme Court of the State of Kansas).
57. Declaration (March 2012) in the matter of the Las Brisas Energy Center *Environmental Defense Fund et al., v. Texas Commission on Environmental Quality*, Cause No. D-1-GN-11-001364 (District Court of Travis County, Texas, 261st Judicial District).
58. Expert Report (April 2012), Supplemental and Rebuttal Expert Report (July 2012), and Supplemental Rebuttal Expert Report (August 2012) on behalf of the states of New Jersey and Connecticut in the matter of the Portland Power plant *State of New Jersey and State of Connecticut (Intervenor-Plaintiff) v. RRI Energy Mid-Atlantic Power Holdings et al.*, Civil Action No. 07-CV-5298 (JKG) (Eastern District of Pennsylvania).
59. Declaration (April 2012) in the matter of the EPA's EGU MATS Rule, on behalf of the Environmental Integrity Project.
60. Expert Report (August 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana) – Harm Phase.
61. Declaration (September 2012) in the Matter of the Application of *Energy Answers Incinerator, Inc.* for a Certificate of Public Convenience and Necessity to Construct a 120 MW Generating Facility in Baltimore City, Maryland, before the Public Service Commission of Maryland, Case No. 9199.

62. Expert Report (October 2012) on behalf of the Appellants (Robert Concilus and Leah Humes) in the matter of Robert Concilus and Leah Humes v. Commonwealth of Pennsylvania Department of Environmental Protection and Crawford Renewable Energy, before the Commonwealth of Pennsylvania Environmental Hearing Board, Docket No. 2011-167-R.
63. Expert Report (October 2012), Supplemental Expert Report (January 2013), and Affidavit (June 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.
64. Pre-filed Testimony (October 2012) on behalf of No-Sag in the matter of the North Springfield Sustainable Energy Project before the State of Vermont, Public Service Board.
65. Pre-filed Testimony (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.
66. Expert Report (February 2013) on behalf of Petitioners in the matter of Credence Crematory, Cause No. 12-A-J-4538 before the Indiana Office of Environmental Adjudication.
67. Expert Report (April 2013), Rebuttal report (July 2013), and Declarations (October 2013, November 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
68. Declaration (April 2013) on behalf of Petitioners in the matter of *Sierra Club, et al., (Petitioners) v. Environmental Protection Agency et al. (Respondents)*, Case No., 13-1112, (Court of Appeals, District of Columbia Circuit).
69. Expert Report (May 2013) and Rebuttal Expert Report (July 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).
70. Declaration (August 2013) on behalf of A. J. Acosta Company, Inc., in the matter of *A. J. Acosta Company, Inc., v. County of San Bernardino*, Case No. CIVSS803651.
71. Comments (October 2013) on behalf of the Washington Environmental Council and the Sierra Club in the matter of the Washington State Oil Refinery RACT (for Greenhouse Gases), submitted to the Washington State Department of Ecology, the Northwest Clean Air Agency, and the Puget Sound Clean Air Agency.
72. Statement (November 2013) on behalf of various Environmental Organizations in the matter of the Boswell Energy Center (BEC) Unit 4 Environmental Retrofit Project, to the Minnesota Public Utilities Commission, Docket No. E-015/M-12-920.
73. Expert Report (December 2013) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
74. Expert Testimony (December 2013) on behalf of the Sierra Club in the matter of Public Service Company of New Hampshire Merrimack Station Scrubber Project and Cost Recovery, Docket No. DE 11-250, to the State of New Hampshire Public Utilities Commission.
75. Expert Report (January 2014) on behalf of Baja, Inc., in *Baja, Inc., v. Automotive Testing and Development Services, Inc. et. al*, Civil Action No. 8:13-CV-02057-GRA (District of South Carolina, Anderson/Greenwood Division).
76. Declaration (March 2014) on behalf of the Center for International Environmental Law, Chesapeake Climate Action Network, Friends of the Earth, Pacific Environment, and the Sierra Club (Plaintiffs) in the matter of *Plaintiffs v. the Export-Import Bank (Ex-Im Bank) of the United States*, Civil Action No. 13-1820 RC (District Court for the District of Columbia).

77. Declaration (April 2014) on behalf of Respondent-Intervenors in the matter of *Mexichem Specialty Resins Inc., et al., (Petitioners) v Environmental Protection Agency et al.*, Case No., 12-1260 (and Consolidated Case Nos. 12-1263, 12-1265, 12-1266, and 12-1267), (Court of Appeals, District of Columbia Circuit).
78. Direct Prefiled Testimony (June 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17319 (Michigan Public Service Commission).
79. Expert Report (June 2014) on behalf of ECM Biofilms in the matter of the US Federal Trade Commission (FTC) v. ECM Biofilms (FTC Docket #9358).
80. Direct Prefiled Testimony (August 2014) on behalf of the Michigan Environmental Council and the Sierra Club in the matter of the Application of Consumers Energy Company for Authority to Implement a Power Supply Cost Recovery (PSCR) Plan in its Rate Schedules for 2014 Metered Jurisdictional Sales of Electricity, Case No. U-17317 (Michigan Public Service Commission).
81. Declaration (July 2014) on behalf of Public Health Intervenors in the matter of *EME Homer City Generation v. US EPA* (Case No. 11-1302 and consolidated cases) relating to the lifting of the stay entered by the Court on December 30, 2011 (US Court of Appeals for the District of Columbia).
82. Expert Report (September 2014), Rebuttal Expert Report (December 2014) and Supplemental Expert Report (March 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and PacifiCorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).
83. Expert Report (November 2014) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).
84. *Declaration (January 2015) relating to Startup/Shutdown in the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.*
85. Pre-filed Direct Testimony (March 2015), Supplemental Testimony (May 2015), and Surrebuttal Testimony (December 2015) on behalf of Friends of the Columbia Gorge in the matter of the Application for a Site Certificate for the Troutdale Energy Center before the Oregon Energy Facility Siting Council.
86. Brief of Amici Curiae Experts in Air Pollution Control and Air Quality Regulation in Support of the Respondents, On Writs of Certiorari to the US Court of Appeals for the District of Columbia, No. 14-46, 47, 48. *Michigan et. al., (Petitioners) v. EPA et. al., Utility Air Regulatory Group (Petitioners) v. EPA et. al., National Mining Association et. al., (Petitioner) v. EPA et. al.*, (Supreme Court of the United States).
87. Expert Report (March 2015) and Rebuttal Expert Report (January 2016) on behalf of Plaintiffs in the matter of *Conservation Law Foundation v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).
88. Declaration (April 2015) relating to various Technical Corrections for the MATS Rule (EPA Docket ID No. EPA-HQ-OAR-2009-0234) on behalf of the Environmental Integrity Project.
89. Direct Prefiled Testimony (May 2015) on behalf of the Michigan Environmental Council, the Natural Resources Defense Council, and the Sierra Club in the matter of the Application of DTE Electric Company for Authority to Increase its Rates, Amend its Rate Schedules and Rules Governing the Distribution and Supply of Electric Energy and for Miscellaneous Accounting Authority, Case No. U-17767 (Michigan Public Service Commission).
90. Expert Report (July 2015) and Rebuttal Expert Report (July 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).

91. Declaration (August 2015, Docket No. 1570376) in support of “Opposition of Respondent-Intervenors American Lung Association, et. al., to Tri-State Generation’s Emergency Motion;” Declaration (September 2015, Docket No. 1574820) in support of “Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors for Remand Without Vacatur;” Declaration (October 2015) in support of “Joint Motion of the State, Local Government, and Public Health Respondent-Intervenors to State and Certain Industry Petitioners’ Motion to Govern, *White Stallion Energy Center, LLC v. US EPA*, Case No. 12-1100 (US Court of Appeals for the District of Columbia).
92. Declaration (September 2015) in support of the Draft Title V Permit for Dickerson Generating Station (Proposed Permit No 24-031-0019) on behalf of the Environmental Integrity Project.
93. Expert Report (Liability Phase) (December 2015) and Rebuttal Expert Report (February 2016) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., Environmental Law and Policy Center, and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
94. Declaration (December 2015) in support of the Petition to Object to the Title V Permit for Morgantown Generating Station (Proposed Permit No 24-017-0014) on behalf of the Environmental Integrity Project.
95. Expert Report (November 2015) on behalf of Appellants in the matter of *Sierra Club, et al. v. Craig W. Butler, Director of Ohio Environmental Protection Agency et al.*, ERAC Case No. 14-256814.
96. Affidavit (January 2016) on behalf of Bridgewatch Detroit in the matter of *Bridgewatch Detroit v. Waterfront Petroleum Terminal Co., and Waterfront Terminal Holdings, LLC.*, in the Circuit Court for the County of Wayne, State of Michigan.
97. Expert Report (February 2016) and Rebuttal Expert Report (July 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.
98. Direct Testimony (May 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.
99. Declaration (June 2016) relating to deficiencies in air quality analysis for the proposed Millenium Bulk Terminal, Port of Longview, Washington.
100. Declaration (December 2016) relating to EPA’s refusal to set limits on PM emissions from coal-fired power plants that reflect pollution reductions achievable with fabric filters on behalf of Environmental Integrity Project, Clean Air Council, Chesapeake Climate Action Network, Downwinders at Risk represented by Earthjustice in the matter of *ARIPPA v EPA, Case No. 15-1180*. (D.C. Circuit Court of Appeals).
101. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
102. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Backus Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
103. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Drakulic Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
104. Expert Report (January 2017) on the Environmental Impacts Analysis associated with the Apex Energy Deutsch Well Pad on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
105. Affidavit (February 2017) pertaining to deficiencies water discharge compliance issues at the Wood River Refinery in the matter of *People of the State of Illinois (Plaintiff) v. Phillips 66 Company, ConocoPhillips Company, WRB Refining LP (Defendants)*, Case No. 16-CH-656, (Circuit Court for the Third Judicial Circuit, Madison County, Illinois).

106. Expert Report (March 2017) on behalf of the Plaintiff pertaining to non-degradation analysis for waste water discharges from a power plant in the matter of *Sierra Club (Plaintiff) v. Pennsylvania Department of Environmental Protection (PADEP) and Lackawanna Energy Center*, Docket No. 2016-047-L (consolidated), (Pennsylvania Environmental Hearing Board).
107. Expert Report (March 2017) on behalf of the Plaintiff pertaining to air emissions from the Heritage incinerator in East Liverpool, Ohio in the matter of *Save our County (Plaintiff) v. Heritage Thermal Services, Inc. (Defendant)*, Case No. 4:16-CV-1544-BYP, (US District Court for the Northern District of Ohio, Eastern Division).
108. Rebuttal Expert Report (June 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight (Plaintiffs) v Coyote Creek Mining Company LLC (Defendant)*, Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).
109. Expert Affidavit (August 2017) and Penalty/Remedy Expert Affidavit (October 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant,)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).
110. Expert Report (August 2017) on behalf of Appellant in the matter of *Patricia Ann Troiano (Appellant) v. Upper Burrell Township Zoning Hearing Board (Appellee)*, Court of Common Pleas of Westmoreland County, Pennsylvania, Civil Division.
111. Expert Report (October 2017), Supplemental Expert Report (October 2017), and Rebuttal Expert Report (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).
112. Declaration (December 2017) on behalf of the Environmental Integrity Project in the matter of permit issuance for ATI Flat Rolled Products Holdings, Breckenridge, PA to the Allegheny County Health Department.
113. Expert Report (Harm Phase) (January 2018), Rebuttal Expert Report (Harm Phase) (May 2018) and Supplemental Expert Report (Harm Phase) (April 2019) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
114. Declaration (February 2018) on behalf of the Chesapeake Bay Foundation, et. al., in the matter of the Section 126 Petition filed by the state of Maryland in *State of Maryland v. Pruitt (Defendant)*, Civil Action No. JKB-17-2939 (Consolidated with No. JKB-17-2873) (US District Court for the District of Maryland).
115. Direct Pre-filed Testimony (March 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of *NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC*, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).
116. Expert Affidavit (April 2018) and Second Expert Affidavit (May 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.
117. Direct Pre-filed Testimony and Affidavit (December 2018) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).
118. Expert Report (February 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.
119. Declaration (March 2019) on behalf of Earthjustice in the matter of comments on the renewal of the Title V Federal Operating Permit for Valero Houston refinery.

120. Expert Report (March 2019) on behalf of Plaintiffs for Class Certification in the matter of *Resendez et al v Precision Castparts Corporation* in the Circuit Court for the State of Oregon, County of Multnomah, Case No. 16cv16164.
121. Expert Report (June 2019), Affidavit (July 2019) and Rebuttal Expert Report (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellees) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.
122. Affidavit/Expert Report (August 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.
123. Expert Report (October 2019) relating to the appeal of air permit (Plan Approval) on behalf of Appellants in the matter of *Clean Air Council and Environmental Integrity Project (Appellants) v. Commonwealth of Pennsylvania Department of Environmental Protection and Sunoco Partners Marketing and Terminals L.P.*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-057-L.
124. Expert Report (December 2019) on behalf of Earthjustice in the matter of *Objection to the Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation*, Dale, Indiana, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.
125. Affidavit (December 2019) on behalf of Plaintiff-Intervenor (Surfrider Foundation) in the matter of *United States and the State of Indiana (Plaintiffs), Surfrider Foundation (Plaintiff-Intervenor), and City of Chicago (Plaintiff-Intervenor) v. United States Steel Corporation (Defendant)*, Civil Action No. 2:18-cv-00127 (US District Court for the Northern District of Indiana, Hammond Division).
126. Declaration (February 2020) in support of Petitioner's Motion for Stay of PSCAA NOC Order of Approval No. 11386 in the matter of the *Puyallup Tribe of Indians v. Puget Sound Clean Air Agency (PSCAA) and Puget Sound Energy (PSE)*, before the State of Washington Pollution Control Hearings Board, PCHB No. P19-088.

C. Occasions where Dr. Sahu has provided oral testimony in depositions, at trial or in similar proceedings include the following:

127. Deposition on behalf of Rocky Mountain Steel Mills, Inc. located in Pueblo, Colorado – dealing with the manufacture of steel in mini-mills including methods of air pollution control and BACT in steel mini-mills and opacity issues at this steel mini-mill.
128. Trial Testimony (February 2002) on behalf of Rocky Mountain Steel Mills, Inc. in Denver District Court.
129. Trial Testimony (February 2003) on behalf of the United States in the Ohio Edison NSR Cases, *United States, et al. v. Ohio Edison Co., et al.*, C2-99-1181 (Southern District of Ohio).
130. Trial Testimony (June 2003) on behalf of the United States in the Illinois Power NSR Case, *United States v. Illinois Power Co., et al.*, 99-833-MJR (Southern District of Illinois).
131. Deposition (10/20/2005) on behalf of the United States in connection with the Cinergy NSR Case. *United States, et al. v. Cinergy Corp., et al.*, IP 99-1693-C-M/S (Southern District of Indiana).
132. Oral Testimony (August 2006) on behalf of the Appalachian Center for the Economy and the Environment re. the Western Greenbrier plant, WV before the West Virginia DEP.
133. Oral Testimony (May 2007) on behalf of various Montana petitioners (Citizens Awareness Network (CAN), Women's Voices for the Earth (WVE) and the Clark Fork Coalition (CFC)) re. the Thompson River Cogeneration plant before the Montana Board of Environmental Review.
134. Oral Testimony (October 2007) on behalf of the Sierra Club re. the Sevier Power Plant before the Utah Air Quality Board.

135. Oral Testimony (August 2008) on behalf of the Sierra Club and Clean Water re. Big Stone Unit II before the South Dakota Board of Minerals and the Environment.
136. Oral Testimony (February 2009) on behalf of the Sierra Club and the Southern Environmental Law Center re. Santee Cooper Pee Dee units before the South Carolina Board of Health and Environmental Control.
137. Oral Testimony (February 2009) on behalf of the Sierra Club and the Environmental Integrity Project re. NRG Limestone Unit 3 before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
138. Deposition (July 2009) on behalf of MTD Products, Inc., in the matter of *Alice Holmes and Vernon Holmes v. Home Depot USA, Inc., et al.*
139. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Coletto Creek coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
140. Deposition (October 2009) on behalf of Environmental Defense, in the matter of permit challenges to the proposed Las Brisas coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
141. Deposition (October 2009) on behalf of the Sierra Club, in the matter of challenges to the proposed Medicine Bow Fuel and Power IGL plant in Cheyenne, Wyoming.
142. Deposition (October 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed Tenaska coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH). (April 2010).
143. Oral Testimony (November 2009) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
144. Deposition (December 2009) on behalf of Environmental Defense and others, in the matter of challenges to the proposed White Stallion Energy Center coal fired power plant project at the Texas State Office of Administrative Hearings (SOAH).
145. Oral Testimony (February 2010) on behalf of the Environmental Defense Fund re. the White Stallion Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
146. Deposition (June 2010) on behalf of the United States in connection with the Alabama Power Company NSR Case. *United States v. Alabama Power Company*, CV-01-HS-152-S (Northern District of Alabama, Southern Division).
147. Trial Testimony (September 2010) on behalf of Commonwealth of Pennsylvania – Dept. of Environmental Protection, State of Connecticut, State of New York, State of Maryland, and State of New Jersey (Plaintiffs) in connection with the Allegheny Energy NSR Case in US District Court in the Western District of Pennsylvania. *Plaintiffs v. Allegheny Energy Inc., et al.*, 2:05cv0885 (Western District of Pennsylvania).
148. Oral Direct and Rebuttal Testimony (September 2010) on behalf of Fall-Line Alliance for a Clean Environment and others in the matter of the PSD Air Permit for Plant Washington issued by Georgia DNR at the Office of State Administrative Hearing, State of Georgia (OSAH-BNR-AQ-1031707-98-WALKER).
149. Oral Testimony (September 2010) on behalf of the State of New Mexico Environment Department in the matter of Proposed Regulation 20.2.350 NMAC – *Greenhouse Gas Cap and Trade Provisions*, No. EIB 10-04 (R), to the State of New Mexico, Environmental Improvement Board.
150. Oral Testimony (October 2010) on behalf of the Environmental Defense Fund re. the Las Brisas Energy Center before the Texas State Office of Administrative Hearings (SOAH) Administrative Law Judges.
151. Oral Testimony (November 2010) regarding BART for PSCo Hayden, CSU Martin Drake units before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.
152. Oral Testimony (December 2010) regarding BART for TriState Craig Units, CSU Nixon Unit, and PRPA Rawhide Unit) before the Colorado Air Quality Commission on behalf of the Coalition of Environmental Organizations.

153. Deposition (December 2010) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
154. Deposition (February 2011 and January 2012) on behalf of Wild Earth Guardians in the matter of opacity exceedances and monitor downtime at the Public Service Company of Colorado (Xcel)'s Cherokee power plant. No. 09-cv-1862 (D. Colo.).
155. Oral Testimony (February 2011) to the Georgia Office of State Administrative Hearings (OSAH) in the matter of Minor Source HAPs status for the proposed Longleaf Energy Associates power plant (OSAH-BNR-AQ-1115157-60-HOWELLS) on behalf of the Friends of the Chattahoochee and the Sierra Club).
156. Deposition (August 2011) on behalf of the United States in *United States of America v. Cemex, Inc.*, Civil Action No. 09-cv-00019-MSK-MEH (District of Colorado).
157. Deposition (July 2011) and Oral Testimony at Hearing (February 2012) on behalf of the Plaintiffs MYTAPN in the matter of Microsoft-Yes, Toxic Air Pollution-No (MYTAPN) v. State of Washington, Department of Ecology and Microsoft Corporation Columbia Data Center to the Pollution Control Hearings Board, State of Washington, Matter No. PCHB No. 10-162.
158. Oral Testimony at Hearing (March 2012) on behalf of the United States in connection with the Louisiana Generating NSR Case. *United States v. Louisiana Generating, LLC*, 09-CV100-RET-CN (Middle District of Louisiana).
159. Oral Testimony at Hearing (April 2012) on behalf of the New Hampshire Sierra Club at the State of New Hampshire Public Utilities Commission, Docket No. 10-261 – the 2010 Least Cost Integrated Resource Plan (LCIRP) submitted by the Public Service Company of New Hampshire (re. Merrimack Station Units 1 and 2).
160. Oral Testimony at Hearing (November 2012) on behalf of Clean Wisconsin in the matter of Application of Wisconsin Public Service Corporation for Authority to Construct and Place in Operation a New Multi-Pollutant Control Technology System (ReACT) for Unit 3 of the Weston Generating Station, before the Public Service Commission of Wisconsin, Docket No. 6690-CE-197.
161. Deposition (March 2013) in the matter of various Environmental Petitioners v. North Carolina DENR/DAQ and Carolinas Cement Company, before the Office of Administrative Hearings, State of North Carolina.
162. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
163. Deposition (August 2013) on behalf of the Sierra Club in connection with the Luminant Martin Lake Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 5:10-cv-0156-MHS-CMC (Eastern District of Texas, Texarkana Division).
164. Deposition (February 2014) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
165. Trial Testimony (February 2014) in the matter of *Environment Texas Citizen Lobby, Inc and Sierra Club v. ExxonMobil Corporation et al.*, Civil Action No. 4:10-cv-4969 (Southern District of Texas, Houston Division).
166. Trial Testimony (February 2014) on behalf of the Sierra Club in connection with the Luminant Big Brown Case. *Sierra Club v. Energy Future Holdings Corporation and Luminant Generation Company LLC*, Civil Action No. 6:12-cv-00108-WSS (Western District of Texas, Waco Division).
167. Deposition (June 2014) and Trial (August 2014) on behalf of ECM Biofilms in the matter of the *US Federal Trade Commission (FTC) v. ECM Biofilms* (FTC Docket #9358).
168. Deposition (February 2015) on behalf of Plaintiffs in the matter of *Sierra Club and Montana Environmental Information Center (Plaintiffs) v. PPL Montana LLC, Avista Corporation, Puget Sound Energy, Portland General Electric Company, Northwestern Corporation, and PacifiCorp (Defendants)*, Civil Action No. CV 13-32-BLG-DLC-JCL (US District Court for the District of Montana, Billings Division).

169. Oral Testimony at Hearing (April 2015) on behalf of Niagara County, the Town of Lewiston, and the Villages of Lewiston and Youngstown in the matter of CWM Chemical Services, LLC New York State Department of Environmental Conservation (NYSDEC) Permit Application Nos.: 9-2934-00022/00225, 9-2934-00022/00231, 9-2934-00022/00232, and 9-2934-00022/00249 (pending).
170. Deposition (August 2015) on behalf of Plaintiff in the matter of *Conservation Law Foundation (Plaintiff) v. Broadrock Gas Services LLC, Rhode Island LFG GENCO LLC, and Rhode Island Resource Recovery Corporation (Defendants)*, Civil Action No. 1:13-cv-00777-M-PAS (US District Court for the District of Rhode Island).
171. Testimony at Hearing (August 2015) on behalf of the Sierra Club in the matter of *Amendments to 35 Illinois Administrative Code Parts 214, 217, and 225* before the Illinois Pollution Control Board, R15-21.
172. Deposition (May 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).
173. Trial Testimony (October 2015) on behalf of Plaintiffs in the matter of *Northwest Environmental Defense Center et. al., (Plaintiffs) v. Cascade Kelly Holdings LLC, d/b/a Columbia Pacific Bio-Refinery, and Global Partners LP (Defendants)*, Civil Action No. 3:14-cv-01059-SI (US District Court for the District of Oregon, Portland Division).
174. Deposition (April 2016) on behalf of the Plaintiffs in *Natural Resources Defense Council, Respiratory Health Association, and Sierra Club (Plaintiffs) v. Illinois Power Resources LLC and Illinois Power Resources Generation LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (Central District of Illinois, Peoria Division).
175. Trial Testimony at Hearing (July 2016) in the matter of Tesoro Savage LLC Vancouver Energy Distribution Terminal, Case No. 15-001 before the State of Washington Energy Facility Site Evaluation Council.
176. Trial Testimony (December 2016) on behalf of the challengers in the matter of the Delaware Riverkeeper Network, Clean Air Council, et. al., vs. Commonwealth of Pennsylvania Department of Environmental Protection and R. E. Gas Development LLC regarding the Geyer well site before the Pennsylvania Environmental Hearing Board.
177. Trial Testimony (July-August 2016) on behalf of the United States in *United States of America v. Ameren Missouri*, Civil Action No. 4:11-cv-00077-RWS (Eastern District of Missouri, Eastern Division).
178. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Huntley and Huntley Poseidon Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
179. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Backus Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
180. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Drakulic Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
181. Trial Testimony (January 2017) on the Environmental Impacts Analysis associated with the Apex energy Deutsch Well Pad Hearing on behalf citizens in the matter of the special exception use Zoning Hearing Board of Penn Township, Westmoreland County, Pennsylvania.
182. Deposition Testimony (July 2017) on behalf of Plaintiffs in the matter of *Casey Voight and Julie Voight v Coyote Creek Mining Company LLC (Defendant)* Civil Action No. 1:15-CV-00109 (US District Court for the District of North Dakota, Western Division).
183. Deposition Testimony (November 2017) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).

184. Deposition Testimony (December 2017) on behalf of Plaintiff in the matter of *Wildearth Guardians (Plaintiff) v Colorado Springs Utility Board (Defendant)* Civil Action No. 1:15-cv-00357-CMA-CBS (US District Court for the District of Colorado).
185. Deposition Testimony (January 2018) in the matter of National Parks Conservation Association (NPCA) v. State of Washington Department of Ecology and British Petroleum (BP) before the Washington Pollution Control Hearing Board, Case No. 17-055.
186. Trial Testimony (January 2018) on behalf of Defendant in the matter of *Oakland Bulk and Oversized Terminal (Plaintiff) v City of Oakland (Defendant,)* Civil Action No. 3:16-cv-07014-VC (US District Court for the Northern District of California, San Francisco Division).
187. Trial Testimony (April 2018) on behalf of the National Parks Conservation Association (NPCA) in the matter of NPCA v State of Washington, Department of Ecology and BP West Coast Products, LLC, PCHB No. 17-055 (Pollution Control Hearings Board for the State of Washington).
188. Deposition (June 2018) (harm Phase) on behalf of Plaintiffs in the matter of *Natural Resources Defense Council, Inc., Sierra Club, Inc., and Respiratory Health Association v. Illinois Power Resources LLC, and Illinois Power Resources Generating LLC (Defendants)*, Civil Action No. 1:13-cv-01181 (US District Court for the Central District of Illinois, Peoria Division).
189. Trial Testimony (July 2018) on behalf of Petitioners in the matter of *Coosa River Basin Initiative and Sierra Club (Petitioners) v State of Georgia Environmental Protection Division, Georgia Department of Natural Resources (Respondent) and Georgia Power Company (Intervenor/Respondent)*, Docket Nos: 1825406-BNR-WW-57-Howells and 1826761-BNR-WW-57-Howells, Office of State Administrative Hearings, State of Georgia.
190. Deposition (January 2019) and Trial Testimony (January 2019) on behalf of Sierra Club and Texas Campaign for the Environment (Appellants) in the contested case hearing before the Texas State Office of Administrative Hearings in Docket Nos. 582-18-4846, 582-18-4847 (Application of GCGV Asset Holding, LLC for Air Quality Permit Nos. 146425/PSDTX1518 and 146459/PSDTX1520 in San Patricio County, Texas).
191. Deposition (February 2019) and Trial Testimony (March 2019) on behalf of Sierra Club in the State of Florida, Division of Administrative Hearings, Case No. 18-2124EPP, Tampa Electric Company Big Bend Unit 1 Modernization Project Power Plant Siting Application No. PA79-12-A2.
192. Deposition (June 2019) relating to the appeal of air permits issued to PTTGCA on behalf of Appellants in the matter of *Sierra Club (Appellants) v. Craig Butler, Director, et. al., Ohio EPA (Appellees)* before the State of Ohio Environmental Review Appeals Commission (ERAC), Case Nos. ERAC-19-6988 through -6991.
193. Deposition (September 2019) on behalf of Appellants relating to the NPDES permit for the Cheswick power plant in the matter of *Three Rivers Waterkeeper and Sierra Club (Appellees) v. State of Pennsylvania Department of Environmental Protection (Appellee) and NRG Power Midwest (Permittee)*, before the Commonwealth of Pennsylvania Environmental Hearing Board, EHB Docket No. 2018-088-R.
194. Deposition (December 2019) on behalf of the Plaintiffs in the matter of David Kovac, individually and on behalf of wrongful death class of Irene Kovac v. Bp Corporation North America Inc., Circuit Court of Jackson County, Missouri (Independence), Case No. 1816-CV12417.
195. Deposition (February 2020) on behalf of Earthjustice in the matter of *Objection to the Issuance of PSD/NSR and Title V permits for Riverview Energy Corporation*, Dale, Indiana, before the Indiana Office of Environmental Adjudication, Cause No. 19-A-J-5073.